

AD-A007 966

AGARD INDEX OF PUBLICATIONS,  
1971-1973

Advisory Group for Aerospace Research and  
Development  
Paris, France

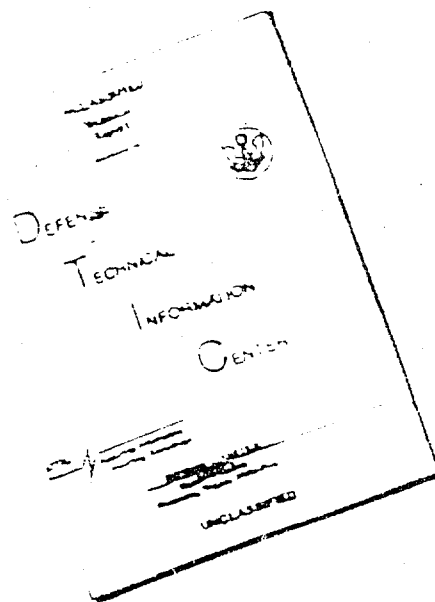
1974

DISTRIBUTED BY:

**NTIS**

National Technical Information Service  
U. S. DEPARTMENT OF COMMERCE

# DISCLAIMER NOTICE



THIS DOCUMENT IS BEST  
QUALITY AVAILABLE. THE COPY  
FURNISHED TO DTIC CONTAINED  
A SIGNIFICANT NUMBER OF  
PAGES WHICH DO NOT  
REPRODUCE LEGIBLY.

REPRODUCED FROM  
BEST AVAILABLE COPY



AD-A007966

AGARD-INDEX

NORTH ATLANTIC TREATY ORGANIZATION  
ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT  
(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

AGARD INDEX OF PUBLICATIONS

1971 - 1973

Reproduced by  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
US Department of Commerce  
Springfield, VA. 22151

This Index has been prepared as part of the programme of the  
Technical Information Panel of AGARD

(423)

## THE MISSION OF AGARD

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each member nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Program and the Aerospace Applications Studies Program. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

The content of this publication has been reproduced directly from material supplied by AGARD or the authors.

Published November 1974

Copyright © AGARD 1974

083.86:025.3

National Technical Information Service is authorized to reproduce and sell this report.



Printed by Technical Editing and Reproduction Ltd  
Harford House, 7-9 Charlotte St. London. W1P 1HD

## PREFACE

This index, for AGARD publications published during the period 1971-1973, differs from previous AGARD Indexes in that the Abstract Section (Part I) and the indexes (Part II) have been consolidated under a single cover.

By an arrangement with the U.S. National Aeronautics and Space Administration in Washington, the NASA computerized data base and abstracts have been used to prepare this publication.

There are five indexes - Subject, based on NASA Thesaurus nomenclature, Personal Author, Corporate Source, Report Number, and Accession Number. Sample entries will be found on the first page of each index.

The 34 NASA categories have been used for abstract location. Abstracts are arranged by series and year in each category - N10,000 Series (STAR), and X70,000 Series, in that order. Abstract lookup from the indexes has been facilitated by use of page numbers. A typical citation with abstract is located immediately after the Table of Contents.

# TABLE OF CONTENTS

## PART I: ABSTRACTS

*Abstracts are grouped under the following subject categories*

<b>01 Aerodynamics</b>	<b>1</b>
Includes aerodynamics of bodies, combinations, internal flow in ducts and turbomachinery; wings, rotors, and control surfaces. For applications see: 02 Aircraft and 32 Space Vehicles. For related information see also: 12 Fluid Mechanics; and 33 Thermodynamics and Combustion.	
<b>02 Aircraft</b>	<b>25</b>
Includes fixed-wing airplanes, helicopters, gliders, balloons, ornithopters, etc.; and specific types of complete aircraft (e.g., ground effect machines, STOL, and VTOL), flight tests; operating problems (e.g., sonic boom); safety and safety devices; economics; and stability and control. For basic research see: 01 Aerodynamics. For related information see also: 31 Space Vehicles, and 32 Structural Mechanics.	
<b>03 Auxiliary Systems</b>	<b>63</b>
Includes fuel cells, energy conversion cells, and solar cells, auxiliary gas turbines; hydraulic, pneumatic and electrical systems; actuators; and inverters. For related information see also: 09 Electronic Equipment; 22 Nuclear Engineering; and 28 Propulsion Systems.	
<b>04 Biosciences</b>	<b>67</b>
Includes aerospace medicine, exobiology, radiation effects on biological systems, physiological and psychological factors. For related information see also: 05 Biotechnology.	
<b>05 Biotechnology</b>	<b>91</b>
Includes life support systems, human engineering, protective clothing and equipment, crew training and evaluation, and piloting. For related information see also: 04 Biosciences.	
<b>06 Chemistry</b>	<b>111</b>
Includes chemical analysis and identification (e.g., spectroscopy). For applications see: 17 Materials, Metallic, 18 Materials, Nonmetallic, and 27 Propellants.	
<b>07 Communications</b>	<b>113</b>
Includes communications equipment and techniques, noise, radio and communications blackout, modulation telemetry, tracking radar and optical observation, and wave propagation. For basic research see: 23 Physics, General, and 21 Navigation.	

<b>08 Computers</b>	<b>151</b>
Includes computer operation and programming, and data processing. For applications, see specific categories. For related information see also: 19 Mathematics.	

<b>09 Electronic Equipment</b>	<b>No Abstracts</b>
Includes electronic test equipment and maintainability; component parts, e.g., electron tubes, tunnel diodes, transistors, integrated circuitry; microminiaturization. For basic research see: 10 Electronics. For related information see also: 07 Communications and 21 Navigation.	

<b>10 Electronics</b>	<b>165</b>
Includes circuit theory; and feedback and control theory. For applications see: 09 Electronic Equipment. For related information see specific Physics categories.	

<b>11 Facilities, Research and Support</b>	<b>171</b>
Includes airports; lunar and planetary bases including associated vehicles; ground support systems, related logistics; simulators; test facilities (e.g., rocket engine test stands, shock tubes, and wind tunnels); test ranges; and tracking stations.	

<b>12 Fluid Mechanics</b>	<b>175</b>
Includes boundary-layer flow; compressible flow; gas dynamics; hydrodynamics; and turbulence. For related information see also: 01 Aerodynamics; and 33 Thermodynamics and Combustion.	

<b>13 Geophysics</b>	<b>187</b>
Includes aeronomy, upper and lower atmosphere studies, oceanography; cartography; and geodesy. For related information see also: 20 Meteorology; 29 Space Radiation; and 30 Space Sciences.	

<b>14 Instrumentation and Photography</b>	<b>189</b>
Includes design, installation, and testing of instrumentation systems; gyroscopes; measuring instruments and gages; recorders; transducers; aerial photography; and telescopes and cameras.	

<b>15 Machine Elements and Processes</b>	<b>197</b>
Includes bearings, seals, pumps, and other mechanical equipment; lubrication, friction, and wear; manufacturing processes and quality control; reliability; drafting; and materials fabrication, handling, and inspection.	

<b>16 Masers</b>	<b>199</b>
Includes applications of masers and lasers. For basic research see: 26 Physics, Solid-State.	

<b>17 Materials, Metallic</b>	<b>201</b>
Includes cermets, corrosion, physical and mechanical properties of materials, metallurgy, and applications as structural materials. For basic research see: 06 Chemistry. For related information see also: 18 Materials, Nonmetallic, and 32 Structural Mechanics.	

<b>18 Materials, Nonmetallic</b>	<b>205</b>	<b>page</b>
Includes corrosion; physical and mechanical properties of materials (e.g., plastics); and elastomers, hydraulic fluids, etc. For basic research see: 06 Chemistry. For related information see also: 17 Materials, Metallic; 27 Propellants; and 32 Structural Mechanics.		
<b>19 Mathematics</b>	<b>No Abstracts</b>	
Includes calculation methods and theory, and numerical analysis. For applications see specific categories. For related information see also: 08 Computers.		
<b>20 Meteorology</b>	<b>217</b>	
Includes climatology; weather forecasting; and visibility studies. For related information see also: 13 Geophysics; and 30 Space Sciences.		
<b>21 Navigation</b>	<b>223</b>	
Includes guidance; autopilots; star and planet tracking; inertial platforms; and air traffic control. For related information see also: 07 Communications.		
<b>22 Nuclear Engineering</b>	<b>No Abstracts</b>	
Includes nuclear reactors and nuclear heat sources used for propulsion and auxiliary power. For basic research see: 24 Physics, Atomic, Molecular, and Nuclear. For related information see also: 03 Auxiliary Systems; and 28 Propulsion Systems.		
<b>23 Physics, General</b>	<b>241</b>	
Includes acoustics, cryogenics, mechanics, and optics. For astrophysics see: 30 Space Sciences. For geophysics and related information see also: 13 Geophysics, 20 Meteorology, and 29 Space Radiation.		
<b>24 Physics, Atomic, Molecular, and Nuclear</b>	<b>No Abstracts</b>	
Includes atomic, molecular and nuclear physics. For applications see: 22 Nuclear Engineering. For related information see also: 29 Space Radiation.		
<b>25 Physics, Plasma</b>	<b>No Abstracts</b>	
Includes magnetohydrodynamics. For applications see: 28 Propulsion Systems.		
<b>26 Physics, Solid-State</b>	<b>No Abstracts</b>	
Includes semiconductor theory; and superconductivity. For applications see: 16 Masers. For related information see also: 10 Electronics.		
<b>27 Propellants</b>	<b>251</b>	
Includes fuels; igniters; and oxidizers. For basic re-		

search see: 06 Chemistry; and 33 Thermodynamics and Combustion. For related information see also: 28 Propulsion Systems.

<b>28 Propulsion Systems</b>	<b>257</b>
Includes air breathing, electric, liquid, solid, and magnetohydrodynamic propulsion. For nuclear propulsion see: 22 Nuclear Engineering. For basic research see: 23 Physics, General; and 33 Thermodynamics and Combustion. For applications see: 31 Space Vehicles. For related information see also: 27 Propellants.	

<b>29 Space Radiation</b>	<b>No Abstracts</b>
Includes cosmic radiation; solar flares, solar radiation, and Van Allen radiation belts. For related information see also: 13 Geophysics; and 24 Physics, Atomic, Molecular, and Nuclear.	

<b>30 Space Sciences</b>	<b>No Abstracts</b>
Includes astronomy and astrophysics, cosmology, lunar and planetary flight and exploration, and theoretical analysis of orbits and trajectories. For related information see also: 11 Facilities, Research and Support, and 31 Space Vehicles.	

<b>31 Space Vehicles</b>	<b>277</b>
Includes launch vehicles; manned space capsules, clustered and multistage rockets; satellites, sounding rockets; and probes; and operating problems. For basic research see: 30 Space Sciences. For related information see also: 28 Propulsion Systems; and 32 Structural Mechanics.	

<b>32 Structural Mechanics</b>	<b>283</b>
Includes structural element design and weight analysis; fatigue, thermal stress, impact phenomena; vibration; flutter; inflatable structures; and structural tests. For related information see also: 17 Materials, Metallic; and 18 Materials, Nonmetallic.	

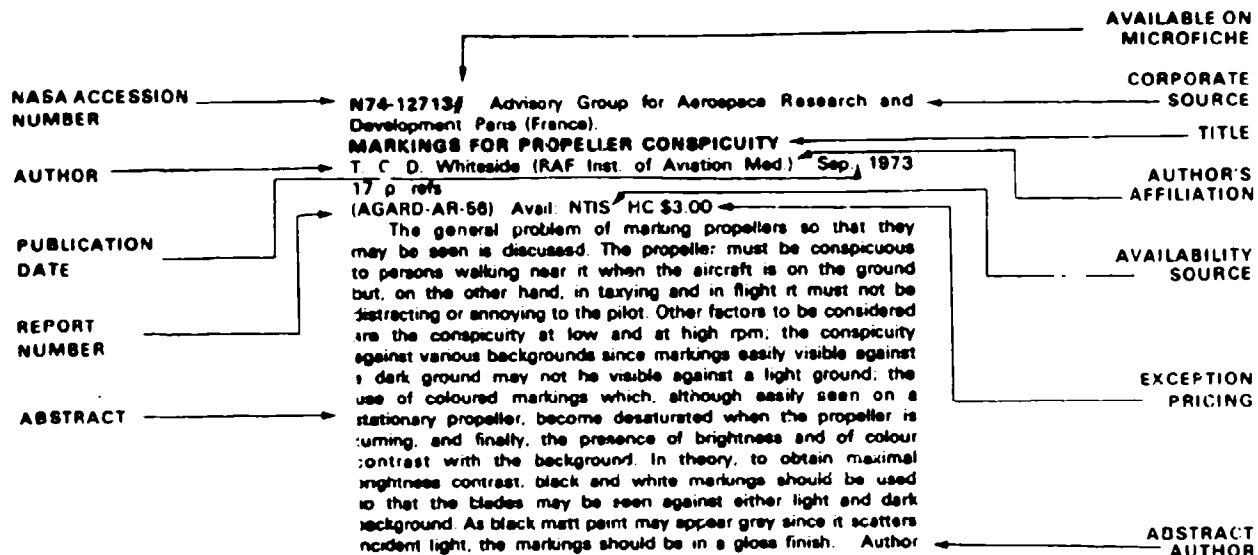
<b>33 Thermodynamics and Combustion</b>	<b>299</b>
Includes ablation, cooling, heating, heat transfer, thermal balance and other thermal effects, and combustion theory. For related information see also: 12 Fluid Mechanics, and 27 Propellants.	

<b>34 General</b>	<b>301</b>
Includes information of a broad nature related to industrial applications and technology, and to basic research; defense aspects; information retrieval, management; law and related legal matters, and legislative hearings and documents.	

## PART II: INDEXES

<b>SUBJECT INDEX</b>	<b>A-I</b>
<b>PERSONAL AUTHOR INDEX</b>	<b>B-I</b>
<b>CORPORATE SOURCE INDEX</b>	<b>C-I</b>
<b>REPORT/ACCESSION NUMBER INDEX</b>	<b>D-I</b>
<b>ACCESSION/REPORT NUMBER INDEX</b>	<b>E-I</b>

## TYPICAL CITATION AND ABSTRACT



# AGARD INDEX OF PUBLICATIONS (1971-1973)

## PART I: ABSTRACTS

### 01 AERODYNAMICS

Includes aerodynamics of bodies, combinations, internal flow in ducts and turbomachinery, wings, rotors, and control surfaces. For applications see 02 Aircraft and 31 Space Vehicles. For related information see also 12 Fluid Mechanics, and 33 Thermodynamics and Combustion.

**N71-17432#** Advisory Group for Aerospace Research and Development, Paris (France)

#### MANUAL ON AEROELASTICITY: SUBJECT AND AUTHOR INDEX

E. C. Pike, ed. Jan 1971. 28 p refs.

(AGARD-R-578-71) Avail NTIS

The Subject Index and Author Index cover all the chapters in the six loose-leaf volumes of the Manual on Aeroelasticity and were up to date in April 1970. Since that date new chapters of the manual have been published in the AGARD Report series. The indexes are published in two forms: in the AGARD Report series as AGARD Report 578 and in loose-leaf form for insertion in Volume VI of the Manual. Entries are given by volume, chapter and page number. For example, II/9/56 denotes Volume II, Chapter 9, page 56. The letter S after a chapter number denotes a supplement to that chapter. The letters TG denote the section of tables and graphs in Volume VI. The abbreviation INTRO denotes the introductory survey in Volume I. Author

**N71-19363#** Advisory Group for Aerospace Research and Development, Paris (France)

#### AERODYNAMIC INTERFERENCE

Jan 1971. 451 p refs. Presented at Fluid Dyn. Panel Specialists' Meeting, Silver Spring, Md., 28-30 Sep 1970.

(AGARD-CP-71-71) Avail NTIS HC\$6 00/MF\$0 95

Aerodynamic interference characteristics of various airframe-propulsion systems for commercial transport and military aircraft are discussed. Wing-fuselage store designs and body-wing and tail configuration effects are emphasized. For individual titles see N71-19354 through N71-19388.

**N71-19364#** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

#### SOME REMARKS ON THE INTERFERENCE BETWEEN A SWEEP WING AND A FUSELAGE

D. Kuechemann. In AGARD Aerodyn Interference Jan 1971. 11 p refs. (See N71-19353 09-01)

Avail NTIS HC\$6 00/MF\$0 95

Principal physical interference effects which occur when a swept (or unswept) wing is joined to a fuselage are analyzed. The flow is dominated by what happens in the junction between

the two bodies; here the interference is largest. The leading terms in the velocity field can be interpreted as being caused in part by the interference with the mirror image in a plane wall of the half wing outside the fuselage. This reflection effect depends mainly on the sweep angle and the dihedral angle. In addition, there is a body interference effect at all sweep and dihedral angles. The method of singularities is applied to calculate the inviscid flow field for some simple cases with and without lift. Theoretical and experimental results demonstrate quite clearly the magnitude of the interference effect. Author

**N71-19365#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)

#### WIND TUNNEL INVESTIGATION OF THE VORTEX SYSTEM NEAR AN INCLINED BODY OF REVOLUTION WITH AND WITHOUT WINGS

F.-H. Grosche. In AGARD Aerodyn Interference Jan 1971. 15 p refs. (See N71-19353 09-01)

Avail NTIS HC\$6 00/MF\$0 95

The flow field on the suction side of a slender body of revolution with and without wings was investigated by means of a directional probe in a 3 m x 3 m low speed wind tunnel. Measurements have been conducted at Mach numbers  $Ma = 0.12$  and Reynolds numbers  $Re = 500,000$ , based on free stream velocity and body diameter. The model was tested at angles of attack  $\alpha = 7$  deg, 10 deg, 15 deg, 20 deg. From the measured data, the cross flow velocities and the isobars of total pressure loss were computed. Position and strength of the vortices were determined as functions of the axial coordinate. There are significant deviations from the results of measurements at high subsonic or supersonic velocities, as well as from measurements at substantially lower Reynolds numbers. The strength of the body vortices is considerably reduced by the presence of the wings. Author

**N71-19366#** Boeing Co., Seattle, Wash. SST Aerodynamics Configuration Group

#### CONSIDERATIONS OF AERODYNAMIC INTERFERENCE IN SUPERSONIC AIRPLANE DESIGN

Edward J. Kane and Wilbur D. Middleton. In AGARD Aerodyn Interference Jan 1971. 16 p refs. (See N71-19353 09-01)

Avail NTIS HC\$6 00/MF\$0 95

Methods for optimizing the interferences between aircraft wing and body, wing and engine nacelles, and wing and trimming surfaces in supersonic flow are discussed. Theoretical concepts are reviewed and expanded where necessary to understand the physical relationship that leads to the most favorable arrangement of the configuration components. Specific applications are illustrated by examples employing analyses of both theoretical and experimental data. Author

**N71-19367#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

# RECENT EXPERIENCE IN USING FINITE ELEMENT METHODS FOR THE SOLUTION OF PROBLEMS IN AERODYNAMIC INTERFERENCE

Ralph L. Carmichael / In AGARD Aerodyn. Interference Jan. 1971 5 p refs (See N71-19353 09-01)  
(NASA-TM-X-66884) Avail. NTIS CSCL 200

Discrete sets of elementary solutions of the linearized equations of gas dynamics for solving problems of flow about airplane configurations are combined in such a way that the boundary conditions of zero flow through physical surfaces are satisfied at large numbers of control points on the surfaces. Calculations using discrete elements and discrete control points provide solutions consistent with closed-form solutions that satisfy the boundary conditions everywhere. An existing computer program for predicting the flow about simple wing-body combinations is extended to include bodies other than the main fuselage. Author

N71-19358# National Physical Lab., Teddington (Eng and) Aerodynamics Div.

# THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF WING BODY CONFIGURATIONS AT LOW SUPERSONIC SPEEDS

J. Bridgewater, R. C. Lock, and G. F. Lee / In AGARD Aerodyn. Interference Jan. 1971 11 p refs (See N71-19353 01-01)  
Avail. NTIS HC\$6.00/MF\$0.95

Wing-body combinations with modifications to the shapes of the basic bodies, wing leading edges and wing roots for reduced drag at transonic and low supersonic speeds were studied. Force and pressure measurements are given for a 55 deg swept wing mounted in turn on two asymmetrically waisted bodies. The first body was designed with the aid of the transonic area rule, and the second was a modified version of this design to give improved performance at low supersonic speeds. Additional experimental results are presented for a second wing having a much blunter leading edge shape so as to give a peaky type of pressure distribution in place of the roof-top pressure distribution of the first wing. Finally considered is the blending of varying wing section shapes near the root of swept wings at supersonic speeds in order to achieve a favorable combined wing-body pressure field inboard on the wind, thus offering the possibility of drag reduction without the use of body waisting. Author

# N71-19359# Technische Hogeschool, Delft (Netherlands) LIFT AND DRAG CHARACTERISTICS OF DELTA WING HALF CONE CONFIGURATIONS WITH SUBSONIC LEADING EDGES, USING SLENDER BODY THEORY

W. J. Bannink and J. W. Reyn / In AGARD Aerodyn. Interference Jan. 1971 11 p refs (See N71-19353 09-01)  
Avail. NTIS HC\$6.00/MF\$0.95

Configurations composed of a cone with a half-circular cross section mounted asymmetrically with respect to a delta wing of zero thickness with subsonic leading edges and placed in a supersonic flow, are studied using slender body theory. The lift and drag characteristics are compared to those of configurations having an identical wing and a symmetrically disposed circular cone of equal volume as the half cone. A disposition of a half cone on one side of the delta wing shows a drag reduction at a given lift compared to the symmetrical full cone configuration, provided the body diameter-wing span ratio is larger than 0.45 approximately. However, the high wing disposition is preferable to the low wing, since lower angles of incidence are required to attain a certain lift. Below the ratio of 0.45 the symmetrical system appears to be more favorable. The lift curve slopes of asymmetrical configurations studied are larger than those of symmetrical configurations. Author

# N71-19360# Messerschmitt-Boelkow G.m.b.H., Munich (West Germany) DOWNWASH INVESTIGATIONS ON TAILS OF MISSILES

G. Gregoriou and I. Laude (DFVLR, Brunswick, West Germany) / In AGARD Aerodyn. Interference Jan. 1971 14 p refs (See N71-19353 09-01)  
Avail. NTIS HC\$6.00/MF\$0.95

A numerical method was developed to calculate the downwash and hence the forces and moments on missile tails. This method is principally based on the linear lifting surface theory and can be applied in the compressible subsonic range at any angle of attack and bank. The results of the calculation indicate a nonlinear dependence of the average downwash angle on the angle of attack. Generally, theoretical results show good agreement with wind tunnel tests. Author

# N71-19361# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va. EXTENSION OF A NUMERICAL SOLUTION FOR THE AERODYNAMIC CHARACTERISTICS OF A WING TO INCLUDE A CANARD OR HORIZONTAL TAIL

Berrett L. Shrout / In AGARD Aerodyn. Interference Jan. 1971 12 p refs (See N71-19353 09-01)  
(NASA-TM-X-66886) Avail. NTIS CSCL 200

A method for predicting the aerodynamic lifting surface characteristics of wing-horizontal tail configurations or canard wing configurations at supersonic speeds is discussed. The numerical solution has been programmed for a digital computer and is part of a complex of computer programs used in the design, optimization, and evaluation of aircraft configurations at supersonic speeds. The present method predicts lift, drag, and moment characteristics over a range of lift coefficients and for various control settings. Theoretical and experimental data are compared for wing-horizontal tail configurations and for canard-wing configurations at various Mach numbers. These comparisons show both the basic data with control deflections and some final trimmed drag polars. Some data are also presented to show the extent to which program limitations affect the accuracy of the analytic methods. Author

N71-19362# Office National d'Etudes et de Recherches Aérospatiales Paris (France)

# CALCULATION OF AERODYNAMIC INTERACTIONS BETWEEN LIFTING ELEMENTS OF AN AIRPLANE IN SUPERSONIC STATIONARY OR NONSTATIONARY FLOW [CALCUL D'INTERACTIONS AERODYNAMIQUES ENTRE LES ELEMENTS PORTANTS D'UN AVION EN ECOULEMENT SUPERSONIQUE STATIONNAIRE OU INSTATIONNAIRE]

Michel Enselme, Jean-Paul Boisseau, and Andre Guillois / In AGARD Aerodyn. Interference Jan. 1971 7 p refs In FRENCH, ENGLISH summary (See N71-19353 09-01)  
Avail. NTIS HC\$6.00/MF\$0.95

After recalling the principle of analog computation of a lifting assembly in supersonic steady or unsteady flow a numerical process is presented that uses an explicit method for computing the solutions of the wave equation. Results obtained either by analog or by numerical computations are presented for wing-body or wing-pod interactions and for a wing of arbitrary planform in unsteady flow. Author

N71-19363# Naval Ship Research and Development Center, Washington, D.C.

# THE EFFECT OF ANGLE OF ATTACK ON INDUCED ROLLING MOMENT FOR A LOW ASPECT RATIO MISSILE

Raymond P. Le Beau / In AGARD Aerodyn. Interference Jan. 1971 11 p refs (See N71-19353 09-01)  
Avail. NTIS HC\$6.00/MF\$0.95

Two wind tunnel tests were conducted to examine the characteristics of the induced rolling moment of two small span missile configurations at transonic Mach numbers for angles of attack up to 90 deg. The induced rolling moment at a roll angle of 22.5 deg was found to increase with angle of attack to a peak value then remain near that value to 90 deg. This peak occurred



at angles between 25 deg and 40 deg. It was also observed that negative values of induced rolling moment at a roll angle of 22.5 deg occurred for one configuration when the angle of attack was less than 20 deg. Author

**N71-19364#** National Aerospace Lab., Amsterdam (Netherlands); Dept for Theoretical Aerodynamics.

**AN APPROXIMATE METHOD FOR THE CALCULATION OF THE PRESSURE DISTRIBUTION ON WING BODY COMBINATIONS AT SUBCRITICAL SPEEDS**

Th. E. Labrujere, W. Loeve, and J. W. Slooff *In AGARD Aerodyn Interference Jan. 1971 17 p refs (See N71-19353 09-01)*  
Avail. NTIS HC\$6.00/MF\$0.95

A method is described which makes it possible to calculate accurate pressure distributions on lifting configurations at Mach numbers up to the critical value. The compressible flow around a configuration is related to an incompressible flow by means of Goethert's rule, which is supplemented semi-empirically. The iterative scheme for solving the large system of linear, simultaneous equations that is involved with the incompressible flow problem is optimized. Assuming a simple wake configuration, the method has been applied to a number of lifting wing-body combinations. Comparisons with measured pressure distributions show that the method can be used when studying wing-body interference problems in subcritical, attached flow. Author

**N71-19365#** Naval Ordnance Lab., White Oak, Md.  
**AERODYNAMIC INTERACTION PHENOMENA PRODUCED BY A FIN PROTUBERANCE PARTIALLY IMMersed IN A TURBULENT BOUNDARY LAYER AT MACH 5**

Allen E. Winkelmann *In AGARD Aerodyn Interference Jan. 1971 12 p refs (See N71-19353 09-01)*  
Avail. NTIS HC\$6.00/MF\$0.95

Various flow visualization results are presented for a cylindrically blunted, unswept, unyawed fin partially immersed in a turbulent boundary layer. The model, consisting of a fin-flat plate combination, was mounted on the test plate nozzle wall of a boundary layer channel. Experiments were completed at a nominal Mach number of 5 and nominal free-stream Reynolds numbers per foot of  $2.8 \times 10^6$  and  $7.4 \times 10^6$ . Azobenzene tests show regions of high heat transfer to occur on the flat plate immediately upstream and downstream of the fin. Oil smear tests show in detail the surface shear directions and locations of separated flow which occur on the model. Schlieren and shadowgraph photographs indicate the complex shock wave structure which exists in front of the fin. Author

**N71-19366#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

**FLIGHT AND WIND TUNNEL INVESTIGATION OF INSTALLATION EFFECTS ON UNDERWING SUPERSONIC CRUISE EXHAUST NOZZLES AT TRANSONIC SPEEDS**

Daniel C. Mikkelsen and Bernard J. Blaha *In AGARD Aerodyn Interference Jan. 1971 10 p refs (See N71-19353 09-01)*  
(NASA-TM-X-68887) Avail. NTIS CSCL 20D

A combined flight and wind tunnel test program is being conducted utilizing a modified F-106 aircraft, to investigate airframe installation effects on exhaust nozzle systems mounted on underwing engine nacelles. Flight tests in the transonic speed regime determined nozzle performance and boattail drag for variable flap ejector, conical plug, and auxiliary inlet ejector nozzle concepts. Wind tunnel tests were conducted on isolated models of these nozzles and also on a 1/20-scale model of the F-106 aircraft with simulated underwing engine nacelles. Wing and nacelle pressures from these wind tunnel tests are used to qualitatively explain the observed installation effects. The 1/20-scale model was also used to evaluate the effects of changes in nacelle geometry and angle-of-attack. Author

**N71-19367#** National Aeronautical Establishment, Ottawa (Ontario)

**THE HALF CONE PRESSURE FIELD AND ITS SIGNIFICANCE TO SIDE MOUNTED INTAKES**

O. J. Peake, D. J. Jones, and W. J. Rainbird *In AGARD Aerodyn Interference Jan. 1971 12 p refs (See N71-19353 09-01)*  
Avail. NTIS HC\$6.00/MF\$0.95

The supersonic, inviscid flow field about an isolated half cone has been computed and the result applied to a semi cone intake mounted adjacent to an aircraft fuselage. The pattern of the intake external flow was obtained from an aircraft model tested in a Mach number  $M = 1.8$  airstream, incorporating a 25-degree semi-angle half cone. The fuselage boundary layer approaching the intake was turbulent, corresponding to a Reynolds number of  $0.8 \times 10^6$  based upon the intake capture dimension. The strong, three dimensional character of the interactions that occur between the intake shock system and the fuselage boundary layer imply that any boundary layer control system must be designed to remove the effects of three dimensional rather than two dimensional separations. Author

**N71-19368#** National Aeronautics and Space Administration, Langley Research Center, Langley, Va

**AERODYNAMIC INTERFERENCE BETWEEN EXHAUST SYSTEM AND AIRFRAME**

Jack F. Runkel *In AGARD Aerodyn Interference Jan. 1971 13 p refs (See N71-19353 09-01)*  
(NASA-TM-X-68808) Avail. NTIS CSCL 01A

Mutual aircraft afterbody and engine nozzle interferences are studied by a model experimental investigations of jet interference at subsonic, transonic, and supersonic speeds. Emphasis is placed on twin-engine fuselage configurations with nozzles installed near the terminus of the afterbody where the interactions of the nozzle exhausts and the external stream produce a complex flow field environment. Airframe interferences on nozzle performance considered are installation locations in the afterbody, boattailing ahead of the nozzles, and effects of tails and protuberances. Nozzle shape and jet exhaust interference can alter aircraft performance and stability. The effect on afterbody drag of nozzle exit axial location appears to pose more problems than the lateral spacing of the nozzles. For closely spaced nozzles, the shape of the interlacing between the nozzles has a pronounced effect on afterbody and nozzle performance. Author

**N71-19369#** General Electric Co., Cincinnati, Ohio  
**AIRFRAME/PROPULSION SYSTEM INTEGRATION ANALYSIS USING THE PROPULSION SIMULATOR TECHNIQUE**

John T. Kutney *In AGARD Aerodyn Interference Jan. 1971 21 p refs (See N71-19353 09-01)*  
Avail. NTIS HC\$6.00/MF\$0.95

The propulsion simulator technique was conceived to provide the analysis and evaluation of the total system performance in the wind tunnel of the new high bypass turbofan installations. This technique provides simultaneous simulation of the induction system and the exhaust system flows with correct geometric simulation and allows the total aircraft aerodynamics and the propulsion system interactions to be evaluated together without the use of additional or reference models. Examples of these data are presented including comparison of a C5A type scale model and full scale results of the TF39/B52 installation. The use of this technology for advanced programs of airframe engine integration for both the subsonic and supersonic flight spectrums is discussed. Author

**N71-19370#** Tennessee Univ., Tullahoma, Space Inst.  
**UNSTEADY AERODYNAMICS OF ROTOR BLADES OF A COMPRESSOR UNDER DISTORTED FLOW CONDITIONS**

B. H. Goethert and K. C. Reddy *In AGARD Aerodyn Interference Jan. 1971 13 p refs (See N71-19353 09-01)*  
Avail. NTIS HC\$6.00/MF\$0.95

A theoretical investigation was undertaken to determine the interference effect between oscillating and distorted inlet flow and compressor stall. It was found that the dynamic effects on the single stage characteristics tend to make the stages less sensitive to pressure oscillations since the flow lacks the necessary time for building up the lift of the individual blades of the stage. On the other hand, the spacer volume in the stages themselves and between the stages produce time lags which tend to increase the stage pressure ratio and thus reduce the stall margin of the individual stages. Depending upon the geometry and the type of oscillations, either the beneficial effect of the dynamic response reduction of individual stages at higher frequencies or the detrimental effects of the spacer volume between the stages will prevail.

Author

**N71-19371\*** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

#### STUDIES OF AIRCRAFT FLOW FIELDS AT INLET LOCATIONS

Lyndell S. King and Terence W. Schmitt (Arnold Res. Organ., Inc.) In AGARD Aerodyn. Interference Jan. 1970 10 p refs (See N71-19353 09-01)

(NASA-TM-X-66885) Avail: NTIS HC\$6.00/MF\$0.95

A wind-tunnel investigation of the flow fields about fuselage configurations at transonic and supersonic speeds and at angles of attack up to 24 deg is reported. A family of seven fuselages with different cross sectional shapes was tested in conjunction with two nose shapes, two canopies, and two wings of different sweep. Flow field surveys were performed at two likely inlet locations - ahead of and under the wing - to assess the effects of forebody geometry throughout the Mach number and angle-of-attack envelope. The experimental data particularly indicate the strong influence of the canopy, nose droop, and fuselage shape on flow angularities in the forward survey plane. Nose droop and the canopy both tend to reduce sensitivity to positive angles of attack and to reduce the extent of influence of fuselage lower corner geometry. Under the wing, however, the flow field is dominated by the effects of the wing itself.

Author

**N71-19372\*** National Gas Turbine Establishment, Pyestock (England).

#### SOME RECENT RESEARCH ON SUPERSONIC INTAKES AT NOTE

M. C. Neale and F. W. Armstrong In AGARD Aerodyn. Interference Jan. 1971 18 p refs (See N71-19353 09-01)

Avail: NTIS HC\$6.00/MF\$0.95

Drag investigations covering both supersonic and subsonic flight conditions are described, and attention is focused on the difficulty of minimizing supersonic pre-entry drag while retaining an adequate stability margin. The effects are shown of shear planes of varying strength generated in the supersonic compression field. Reynolds number effects are also described. A brief survey of prospects for mixed compression intakes offering an optimum combination of drag and high pressure recovery in supersonic flight is included.

Author

**N71-19373\*** Boeing Co., Seattle, Wash. Supersonic Transport Div.

#### CONFIGURATION ASPECTS OF PROPULSION INSTALLATION ON SUPERSONIC TRANSPORTS

Albert A. Van Duine, William W. Rhoades, and Walter C. Swan In AGARD Aerodyn. Interference Jan. 1971 8 p (See N71-19353 09-01)

Avail: NTIS HC\$6.00/MF\$0.95

Intake decision closely related to configuration effects are outlined for supersonic transport applications. The general problems of propulsion pod placement and proper integration of pod and wing are discussed. The effects of wing flow field and aircraft maneuvers on intake performance and intake operating envelope are treated. Intake-to-intake and intake-to-wing spacing criteria are established relative to mutual intake interference and wing/body

boundary layer effects. Finally, a propulsion comparison is made between a variable sweep configuration employing double engine pods and a fixed wing configuration employing single engine pods.

Author

**N71-19374\*** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).

#### JET SIMULATION AND JET INTERFERENCE EFFECTS ON TAILPLANE

W. Geissler and R. Wulf In AGARD Aerodyn. Interference Jan. 1971 12 p refs (See N71-19353 09-01)

Avail: NTIS HC\$6.00/MF\$0.95

Extensive wind tunnel tests with jet simulation have been carried out in the low speed wind tunnel on different models of the European Airbus. Bypass engines able to simulate the correct ratios of jet to freestream velocity have been developed and are described. The results of force and downwash measurements show destabilizing influences of the airplane caused by jet-tailplane interference. Several steps have been undertaken in order to minimize these effects: the displacement of the engines in wing-tip direction seemed to be the best solution of this problem. In addition to force measurements on a complete model the determination of magnitude and direction of the flow velocities established the boundaries of jet influence.

Author

**N71-19375\*** British Aircraft Corp., Weybridge (England) Aerodynamics Dept.

#### THE COMPLEX AERODYNAMIC INTERFERENCE PATTERN DUE TO REAR FUSELAGE MOUNTED POWERPLANTS

P. R. G. Williams and D. J. Stewart In AGARD Aerodyn. Interference Jan. 1971 15 p ref (See N71-19353 09-01)

Avail: NTIS HC\$6.00/MF\$0.95

The complex interference effects due to rear fuselage mounted power plants on modern high subsonic aircraft are investigated. Results from wind tunnel and full scale flight tests obtained during design and development of BAC VC10 and 1-11 are discussed. Of particular interest are the favorable interference on the wing and comparisons between twin and four-engined configurations. The influences of changes in fuselage length, nacelle setting and rear fuselage shaping to reduce adverse pressure fields are illustrated. Typical pressure distributions and boundary layer traverses measured on the standard and super VC10 in flight are presented and comparisons are made with wind tunnel results. The data presented are evaluated for the probable mechanism of the complex interference forces set up by the presence of the power plants.

Author

**N71-19376\*** General Dynamics, Convair, San Diego, Calif. EXPERIMENTAL RESULTS OF HIGH BYPASS RATIO TURBOFAN AND WING AERODYNAMIC INTERFERENCE

J. E. Aldridge and J. L. Nye (GE) In AGARD Aerodyn. Interference Jan. 1971 12 p (See N71-19353 09-01)

Avail: NTIS HC\$6.00/MF\$0.95

Results of a wind-tunnel investigation into the interference effects of a pylon-wing-mounted, high-bypass-ratio turbofan on the aerodynamic characteristics of a twin engine subsonic airplane are presented. This was accomplished using a high-pressure, air turbine powered propulsion simulator mounted on a 1/7-scale semispan model of the airplane. Results show that significant interference does exist, and that it varies with free stream Mach number, engine power setting, and lift coefficient. Generally, the drag due to nacelle/body interference increases with Mach number, decreases as engine power is increased, and optimizes with lift coefficient. The interference level is either favorable or unfavorable depending on these parameters. The presence of the nacelle has no measurable effect on wing upper surface pressure distribution, however, wing lower surface, nacelle fan, and turbine cowl distributions are significantly altered.

Author

**N71-19377#** Douglas Aircraft Co., Inc., Santa Monica, Calif  
**DETERMINATION OF LOW SPEED INTERFERENCE EFFECTS BY SUPERPOSITION**

John L. Hess and Suzanne M. Faulkner. In AGARD Aerodyn Interference Jan 1971 15 p refs (See N71-19363 09-01)  
 Avail. NTIS HC\$6 00/MF\$0 95

The application of a computer program for potential flow to problems of estimating aerodynamic interference is reported. Examples are presented of straightforward use of the program to calculate flow about more complicated configurations than could previously be handled. Superposition is also used to conserve computing time. The program greatly expands the usefulness of the superposition method. First, the component flows to be superposed may be any of the very general class of solutions that the program can calculate. Second, by comparing flows calculated by superposition with the same flows calculated exactly by the program, the limits of validity of the superposition principle can be determined with a new precision. Examples are presented of calculated flow fields and of comparisons of exact and superposed solutions. Author

**N71-19378#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

**WIND TUNNEL INVESTIGATION INTO AERODYNAMIC INTERACTIONS INDUCED BY DROP LOADS [ETUDE EN SOUFFLERIE DES INTERACTIONS AERODYNAMIQUES DUES AUX CHARGES LARGABLES]**

J. Christophe and J. Coste. In AGARD Aerodyn Interference Jan 1971 11 p refs. In FRENCH, ENGLISH summary (See N71-19353 09-01)

Avail. NTIS HC\$6 00/MF\$0 95

Techniques for the investigation of aerodynamic interactions induced by drop loads are reviewed and some representative results are reported. Emphasis is placed on direct tracings of dropped load trajectories and microrocket propelled missiles by high speed filming in the wind tunnel. Obtained results are compared with those from a newly developed alternative method of weighing the load in the aerodynamic field of the aircraft and reconstructing its trajectory by computing routine. Author

**N71-19379#** Nielson Engineering and Research, Inc., Palo Alto, Calif

**A CALCULATIVE METHOD FOR PREDICTING STORE SEPARATION TRAJECTORIES AT SPEEDS UP TO THE CRITICAL SPEED**

Jack N. Nielson, Frederick K. Goodwin, and Marjorie F. E. Dillenius. In AGARD Aerodyn Interference Jan 1971 14 p refs. Sponsored by AFFDL (See N71-19353 09-01)

Avail. NTIS HC\$6 00/MF\$0 95

A theory has been developed for predicting the trajectories of external stores dropped from high-speed aircraft up to the critical speed. The method consists of three steps: (1) prediction of the non-uniform flow field in the vicinity of the store, (2) prediction of store forces and moments in the nonuniform flow field, and (3) calculation of the trajectory. A vortex lattice method used for the first step predicts well the flow field velocity components under the wing or fuselage. A simplified slender body method for calculating the normal force and moment on the external store is moderately successful by comparison with experiment. Calculated trajectories based on the simplified method are in fair agreement with experiment. Author

**N71-19380#** Aircraft Research Association, Ltd., Bedford (England)

**EXAMPLES OF AIRFRAME STORE INTERFERENCE**

J. B. Barry. In AGARD Aerodyn Interference Jan 1971 12 p refs (See N71-19353 09-01)

Avail. NTIS HC\$6 00/MF\$0 95

Effects of airframe-store interference on the side force and the drag increment due to pylon mounted underwing stores are discussed. The main features of the sidewash and pressure distributions in the flow field beneath a swept wing are described. It is noted that, while the loads on a store would be expected to vary significantly with its position under the wing, some of the interference forces may be regarded as buoyancy effects, implying opposing forces on the aircraft. Examples of measured side force on stores and pylons show that a qualitative correlation can be obtained with underwing sidewash data. Comparisons of the axial force on stores and pylons and the drag increment with estimates of the freestream drag of the store assembly, are presented and, at low speed and low to moderate  $C_L$ , these demonstrate the expected cancellation of some of the interference forces. Brief descriptions of methods being developed for the prediction of store and pylon side force and installed drag increment are included. Author

**N71-19381#** McDonnell Aircraft Corp., St. Louis, Mo  
**EVALUATION OF THE PREDICTION OF AIRPLANE STORE INTERFERENCE BY LINEAR THEORY**

Gordon G. Grose and Dean R. Bristow. In AGARD Aerodyn Interference Jan 1971 12 p refs (See N71-19353 09-01)

Avail. NTIS HC\$6 00/MF\$0 95

A ring-body analysis computer program is used to calculate the interference flow field at a store location due to a wing-body combination, and the resulting loads applied to the store. Interference loads predicted by linear theory are compared with test data on typical fighter bomber configurations at subsonic and supersonic speeds. The subsonic case consists of stowed load wind tunnel data on a body representing the SUU-16A gun pod mounted on the outboard wing pylon of the F-4C airplane. The supersonic case consists of loads on a sting supported store model in the vicinity of a swept wing-body combination representing a fighter bomber at Mach 1.6. The results of the comparison show the detailed survey of the interference flow field provided by the method, and indicate that it is a promising method of estimating store interference effects from the airplane geometry. Author

**N71-19382#** Breguet-Aviation, Paris (France)

**ANALYSIS OF THE EFFECTS OF EXTERNAL STORES FASTENED UNDER A N ARROW WING ON THE LONGITUDINAL STABILITY OF THAT AIRCRAFT [ANALYSE DE L'INFLUENCE DE CHARGES EXTERNES FIXEES SOUS LA VOILURE D'UN APPAREIL A AILE EN FLECHE SUR LA STABILITE LONGITUDINALE DE CET AVION]**

R. Taisserie. In AGARD Aerodyn Interference Jan 1971 13 p. In FRENCH, ENGLISH summary (See N71-19353 09-01)

Avail. NTIS HC\$6 00/MF\$0 95

Wind tunnel test results show that external stores fastened under a swept wing by pylons decrease longitudinal stability of the aircraft. Most of this stability loss comes from the increased deflection of the horizontal tail due to vortex field development at the pylon's trailing edge. This is caused by the force of the local sideslip at the lower part of the wing that produce a lateral lift force on the pylon. The deflection changes the stability of the aircraft as a function of the angle of attack. Author

**N71-19383#** Boeing Co., Wichita, Kans.

**SEPARATION CRITERIA FOR DENSELY PACKED STORES IN BOMB BAYS**

Richard B. Holloway, Donald L. Sutcliffe, and James D. Woodward. In AGARD Aerodyn Interference Jan 1971 10 p (See N71-19353 09-01)

Avail. NTIS HC\$6 00/MF\$0 95

Separation characteristics of the weapons in the densely packed B-52 bombing system configuration 1224-7 proved to be

dependent on the release sequence, release interval and release airspeed. Several different release sequences were investigated to solve bomb collision problems. A successful sequence was derived which provided satisfactory bomb release characteristics when a minimum clearance of one bomb diameter between adjacent bombs is provided as the bomb clears the guide rails. Flight tests indicated the optimal performance of a three-bay configuration with a minimum release interval of 80 to 50 milliseconds. Author

**N71-19394#** Royal Aircraft Establishment, Farnborough (England)  
**FLIGHT INVESTIGATION OF A TECHNIQUE FOR THE MEASUREMENT OF THE TOTAL AND INTERFERENCE DRAG OF EXTERNAL STORES**

K P King *In* AGARD Aerodyn Interference Jan 1971 13 p refs (See N71-19353 09-01)  
 Avail NTIS HC\$6 00/MF\$0 95

Results are given of the flight investigation of a technique for the measurement of the drag of external stores which can be jettisoned. The technique is to drop the stores and evaluate the store drag from the resultant change in aircraft acceleration along the flight path. In an exploratory series of tests, 1000 lb bombs were dropped from a Hunter aircraft and the variation of the drag due to the stores as they separated from the aircraft was determined. The results indicate that, with this particular aircraft/store combination, there is no significant variation of the total installed drag with C sub L over the range tested but the interference drag varies linearly with C sub L squared. Author

**N71-19385#** General Dynamics/Pomona, Calif  
**A METHOD FOR PREDICTING INTERFERENCE FORCES AND MOMENTS ON AIRCRAFT STORES AT SUBSONIC SPEEDS**

F D Fernandes *In* AGARD Aerodyn Interference Jan 1971 9 p refs (See N71-19353 09-01)  
 Avail NTIS HC\$6 00/MF\$0 95

A method is developed for theoretically predicting the loading on aircraft stores at separation for subsonic flow. The method consists of predicting the flow field about the aircraft by using singularity distributions to represent the aircraft according to linear theory, the effect of the variable interference flow field is integrated over the store by using the free-air load distribution properties of the store locally. Buoyancy effects are included. The loading over each store fin is given special consideration with regard to its interaction with the aircraft pylon and with other store surfaces. A FORTRAN computer program performs the calculations. Effects of aircraft wing, fuselage, pylons, and inlets are included. Store moment calculations under an F-4C aircraft are compared with test data. Author

**N71-19386#** Naval Ship Research and Development Center, Washington, D C

**A STUDY OF CAPTIVE FLIGHT DRAG AND SEPARATION CHARACTERISTICS OF LIFTING BODY (HALF BOMB AND HALF POD) STORE CONFIGURATIONS**

Roger J Furey and C Joseph Martin *In* AGARD Aerodyn Interference Jan 1971 11 p refs (See N71-19353 09-01)  
 Avail NTIS HC\$6 00/MF\$0 95

The use of lifting bodies as a basic shape for externally carried stores is considered as a means of overcoming the large incremental drag and poor separation qualities of the more conventionally shaped aircraft stores. Wind-tunnel tests were conducted on a half-bomb and a half-pod to determine their captive flight drag and separation characteristics. Testing was conducted at Mach numbers of 0.74 and 1.88. The half-bombs were found to have as much as a 35 percent drag reduction, in a simulated captive flight condition, over its equivalent whole-bomb counterpart, and separated cleanly without the use of an ejection force under

all conditions tested. The half-pod configuration produced as much as a 20 percent drag reduction over that of the equivalent whole-pod. It also separated cleanly although an ejection force was necessary in order to prevent a pitch-up maneuver and possible collision at the higher Mach number. Author

**N71-19387#** Naval Ordnance Lab., White Oak, Md

**AIRCRAFT/STORE INTERFERENCE**

Chris A Kalivretanos *In* AGARD Aerodyn Interference Jan 1971 16 p refs (See N71-19353 09-01)  
 Avail NTIS HC\$6 00/MF\$0 95

A series of tests relating to the carriage and separation characteristics of a newly developed rocket launcher pod are reported. The objectives of the tests were to identify those flight conditions under which separation of the launcher might result in damage to the aircraft and to obtain data from which the separation behavior could be predicted. Included in this series of tests was a pod installation force test, a flow-field survey test and a pod jettison test. In each investigation, the loaded and empty rocket launcher pods were suspended from the centerline and outboard shoulder stations of the scaled triple ejector rack located on the inboard wing station of an A-4 aircraft model. The pod tends to pitch nose upward at high aircraft angles of attack and nose downward at low aircraft angles of attack. In full-scale tests the nose of the empty pod collides with the wing of the aircraft when launched from the shoulder station at airspeeds below 250 knots and the tail impacts the rack when launched from the centerline at airspeeds above 400 knots. Author

**N71-19388#** Naval Ship Research and Development Center, Washington, D C

**PREDICTION OF STORE LAUNCH CHARACTERISTICS THROUGH STATISTICAL METHODS**

Michael A Sekellick *In* AGARD Aerodyn Interference Jan 1971 11 p refs (See N71-19353 09-01)  
 Avail NTIS HC\$6 00/MF\$0 95

Two statistical methods are presented which have the capability of generating equations to predict the separation characteristics of airborne stores from aircraft. A mathematical relation was found between a configuration, the launch conditions and the associated trajectory. The aircraft/store combination was described by parameters representing the important geometric and physical features which affect separation behavior. Each launch event was catalogued in terms of such parameters and the resulting separation behavior. This data was then statistically analyzed to predict the outcomes of untried launch situations. Author

**N71-23210#** Advisory Group for Aerospace Research and Development, Paris (France)

**FREQUENCY RESPONSE FUNCTIONS AND HUMAN PILOT MODELLING**

Mar 1971 65 p refs. Mostly in ENGLISH, partly in FRENCH (AGARD-R-580-71) Avail NTIS

**CONTENTS**

- 1 THE ART OF DETERMINING GUST FREQUENCY RESPONSE FUNCTIONS J C Houbolt (Aeren Res Associates of Princeton Inc) p 1-20 refs (See N71-23211 12-01)
- 2 THE EFFECT OF ACTIVE CONTROLS ON STRUCTURAL RESPONSES C F Newberry, J I Arnold and G J Kass (Boeing Co, Wichita, Kans) p 21-44 refs (See N71-23212 12-02)
- 3 TRANSFER FUNCTION OF FLEXIBLE AIRCRAFT TO ATMOSPHERIC TURBULENCE G Coupry (ONERA, Paris, France) p 45-58 refs (See N71-23213 12-02)
- 4 HUMAN PILOT MODELLING H F Huddleston (RAE, Farnborough, Engl) p 59-65 refs (See N71-23214 12-04)

**N71-23211#** Aeronautical Research Associates of Princeton, Inc., N.J.

**THE ART OF DETERMINING GUST FREQUENCY RESPONSE FUNCTION**

John C. Houbolt. In AGARD Freq. Response Functions and Human Pilot Modelling. Mar. 1971. p. 1-20. refs. (See N71-23210 12-01)

Avail. NTIS

The art of determining the frequency response function for gust response, and of deriving the associated structural response parameters  $A$  and  $N_{sub 0}$  is discussed. Measured and computed values are compared to show the degree of success obtained. It is brought out that frequency response determination is a computationally large task and that simplified procedures are needed. Emphasis is also given to the fact that there is not a frequency response function for the airplane, but that there are many depending on flight conditions. A procedure is suggested for helping to establish the appropriate frequency response functions, and the  $A$  and  $N_{sub 0}$  values, for use in design. Author

**N71-23212#** Boeing Co., Wichita, Kans.

**THE EFFECT OF ACTIVE CONTROLS ON STRUCTURAL RESPONSES**

Clifford F. Newberry, James I. Arnold, and Gerald J. Kass. In AGARD Freq. Response Functions and Human Pilot Modelling. Mar. 1971. p. 21-44. refs. (See N71-23210 12-01)

Avail. NTIS

The use of an active control system on large flexible aircraft to improve flying qualities, ride qualities, and to alleviate loads require a good mathematical model. The number of modes to be included is treated from a standpoint of stability and for structural loads evaluation. The verification of the model during flight testing is discussed. Frequency response, transient response, and random response techniques are presented. Presented are two examples: one dealing with a lower structural mode frequency that affects the handling qualities and ride qualities of the aircraft and the other deals with a higher frequency mode that is a stability problem. Consideration for artificial damping of the flutter mode is also presented. Author

**N71-23213#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**TRANSFER FUNCTIONS OF FLEXIBLE AIRCRAFT TO ATMOSPHERIC TURBULENCE [FONCTIONS DE TRANSFERT D'UN AVION SOUPLE A LA TURBULENCE]**

G. Coupry. In AGARD Freq. Response Functions and Human Pilot Modelling. Mar. 1971. p. 45-48. refs. In FRENCH. (See N71-23210 12-01)

Avail. NTIS

Computation and measurement of the transfer function of an aircraft flexible to atmospheric turbulence are reported. After a survey of the usable turbulence models, the computation of the transfer function for isotropic turbulence is discussed; it is shown that it is hardly more complicated than in the case of uniform turbulence. Finally, the methods for measuring the transfer function are described. Author

**N71-23214#** Royal Aircraft Establishment, Farnborough (England). Human Factors Group

**HUMAN PILOT MODELLING**

H. F. Huddleston. In AGARD Freq. Response Functions and Human Pilot Modelling. Mar. 1971. p. 59-65. refs. (See N71-23210 12-01)

Avail. NTIS

Human factors engineering attempts to define pilot transfer functions are considered. Input/output engineering studies show that man as a tracker (1) behaves like a low pass amplifier (2) has a built-in reaction time delay (3) can, in some circumstances,

generate substantial lead or lag characteristics, and (4) behaves as if he responded to some events about twice a second. Author

**N71-29333#** Advisory Group for Aerospace Research and Development, Paris (France).

**SYMPOSIUM ON UNSTEADY AERODYNAMICS FOR AEROELASTIC ANALYSES OF INTERFERING SURFACES. PART 1**

April 1971. 92 p. refs. Held at Tonsberg, Norway. 3-4 Nov. 1970.

(AGARD-CP-80-71) Avail. NTIS

**CONTENTS**

1 SOME CONSIDERATIONS RELATIVE TO THE PREDICTION OF UNSTEADY AIR LOADS ON INTERFERING SURFACES. H. Ashley (Stanford Univ.) 22 p. refs. (See N71-29334 17-01)

2 CALCULATION METHODS FOR UNSTEADY AIRFORCES OF TANDEM SURFACES AND T-TAILS IN SUBSONIC FLOW. D. E. Davis (Royal Aircraft Establishment, Farnborough, England) 22 p. refs. (See N71-29335 17-01)

3 REPRESENTATION OF A WING IN THE LIFTING LINE, APPLICATION OF THE INTERACTION CALCULATIONS OF TWO WINGS IN TANDEM. R. Dat and Y. Afanasyu (Office Natl. d'Etudes et de Recherches Aérospatiales, Paris, France) 17 p. refs. (See N71-29336 17-01)

4 A SUPERSONIC BOX COLLOCATION METHOD FOR THE CALCULATION OF UNSTEADY AIRFORCES OF TANDEM SURFACES. D. L. Woodcock and E. J. York (Royal Aircraft Establishment, Farnborough, England) 26 p. refs. (See N71-29337 17-01)

**N71-29334#** Stanford Univ., Calif.

**SOME CONSIDERATIONS RELATIVE TO THE PREDICTION OF UNSTEADY AIR LOADS ON INTERFERING SURFACES**

H. Ashley. In AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 1. Apr. 1971. 22 p. refs. (See N71-29333 17-01)

Avail. NTIS

Loading singularities inherent in linearized potential theory are classified as local, in the sense that both the nature and magnitude of the singularity are determined by boundary conditions in the inner field, or global, in the sense that the entire boundary value problem must be solved to determine their details. Available results are reviewed relative to discontinuities in surface slope, planform shape, dihedral angle, etc., and suggestions are offered for combining them into numerical solution schemes. With respect to the analysis of interfering lifting surfaces, selected recent activity in the United States on continuous solution of various subsonic and supersonic cases is described. Regarding the area-element or box approach to the latter, it is recommended that an element in the form of a trapezium, similar to that employed by Woodward for steady flow, will also improve the behavior of predicted loads for oscillatory motion of interacting surfaces. Formulas for certain of the required influence coefficients are developed. Some nonlinear effects are examined which are felt to have greater significance for interference problems than for isolated lifting wings. The phenomena include the normal displacement and self-deformation of wakes which induce loads on aft surfaces, the local influences of profile thickness and displacement due to boundary layer growth.

Author

**N71-29335#** Royal Aircraft Establishment, Farnborough (England). **CALCULATION METHODS FOR UNSTEADY AIRFORCES OF TANDEM SURFACES AND T-TAILS IN SUBSONIC FLOW**

D. E. Davis. In AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 1. Apr. 1971. 22 p. refs. (See N71-29333 17-01)

Avail. NTIS

The basis of numerical methods, using continuous distributions of loading, for evaluating oscillatory generalised airforce coefficients for interfering and intersecting surfaces inclined everywhere at small angles to a subsonic mainstream flow is described. Particular application to tandem surfaces and T-tails is discussed briefly. Author

**N71-29336#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**REPRESENTATION OF A WING IN THE LIFTING LINE; APPLICATION OF THE INTERACTION CALCULATIONS OF TWO WINGS IN TANDEM [REPRESENTATION D'UNE AILE PAR DES LIGNES PORTANTES; APPLICATION AU CALCUL DE L'INTERACTION DE DEUX AILES EN TANDEM]**

R. Dat and Y. Akamatsu. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 1. Apr 1971. 17 p. refs. In FRENCH, ENGLISH summary. (See N71-29333 17-01)

Avail NTIS

The simulation of wings by a lattice of lifting lines is summarized for the computation of unsteady aerodynamic forces on combinations including several lifting surfaces, such as wing-horizontal tail or fin-horizontal tail. It can be considered as a compromise between the doublet lattice method which is advantageous for its flexibility, and the so called lifting surface method whose results are more accurate for a given number of collocation points. A numerical program was developed for the application to wings lying in two parallel planes. The particular features of the method of calculation are presented, as well as some numerical results. Author

**N71-29337#** Royal Aircraft Establishment, Farnborough (England)

**A SUPERSONIC BOX COLLOCATION METHOD FOR THE CALCULATION OF UNSTEADY AIRFORCES OF TANDEM SURFACES**

D. L. Woodcock and E. J. York. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 1. Apr 1971. 26 p. refs. (See N71-29333 17-01)

Avail NTIS

A box collocation method is developed for the determination of the airforces on a pair of tandem surfaces (not necessarily coplanar) undergoing small oscillatory displacements in a supersonic flow. The perturbation velocity potential is evaluated at the vertices of a lattice of Mach lines on each wing. The results of the application of the method to a wing-tailplane configuration each of triangular planform are given. Author

**N71-29338#** Advisory Group for Aerospace Research and Development, Paris (France)

**SYMPOSIUM ON UNSTEADY AERODYNAMICS FOR AEROELASTIC ANALYSES OF INTERFERING SURFACES. PART 2**

Apr 1971. 234 p. refs. Held at Tonsberg, Norway. 3-4 Nov 1970

(AGARD-CP-80-71) Avail NTIS

**CONTENTS**

1. SUBSONIC UNSTEADY AIRLOADS ON MULTIPLE LIFTING SURFACES. G. Boehm and H. Schmid (Vereinigte Flugtechnische Werk-Fokker GmbH, Munich, West Germany). 28 p. refs. (See N71-29339 17-01)

2. NEW DEVELOPMENTS AND APPLICATIONS OF THE SUBSONIC DOUBLET-LATTICE METHOD FOR NONPLANAR CONFIGURATIONS. W. P. Rodden, J. P. Giesing, and T. P. Kalman (Douglas Aircraft Co., Inc., Long Beach, Calif.). 29 p. refs. (See N71-29340 17-01)

3. APPLICATION OF AFFDL UNSTEADY LOAD PREDICTION METHOD TO INTERFERING SURFACES. W. J. Mykytow, J. J.

Olsen, and S. J. Pollock (AFSC, Wright-Patterson AFB, Ohio). 24 p. refs. (See N71-29341 17-01)

4. APPLICATION OF UNSTEADY AIRFORCE CALCULATION METHODS TO AGARD INTERFERENCE CONFIGURATIONS. D. E. Davies (RAE, Farnborough, England). 18 p. (See N71-29342 17-01)

5. MEASUREMENT OF UNSTEADY AIR LOADS OF INTERACTION BETWEEN LIFTING SURFACES IN TANDEM. A. Destuynder (Office Natl d'Etudes et de Recherches Aérospatiales, Paris, France). 12 p. refs. (See N71-29343 17-01)

6. T-TAIL AEROELASTIC ANALYSIS FOR FOKKER F28. J. YH and R. J. Zwaan (Vereinigte Flugtechnische Werk-Fokker GmbH, Munich, West Germany). 15 p. refs. (See N71-29344 17-01)

7. SOME RECENT INVESTIGATIONS ON FLUTTER IN SUBSONIC FLOW, CAUSED BY INTERFERENCE AERODYNAMIC FORCES BETWEEN WING AND TAIL OF A VARIABLE GEOMETRY AIRCRAFT. W. Seidel and O. Sensburg

(Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany). 10 p. refs. (See N71-29345 17-01)

8. UNSTEADY AERODYNAMICS FOR WINGS WITH CONTROL SURFACES. H. Tijdeman and R. J. Zwaan (Natl Aero- and Astron Res Inst). 15 p. refs. (See N71-29346 17-01)

9. APPLICATION OF LIFTING SURFACE THEORY TO WINGS PROVIDED WITH CONTROL SURFACES. B. Darras and R. Dat (Office Natl d'Etudes et de Recherches Aérospatiales, Paris, France). 14 p. refs. (See N71-29347 17-01)

10. UNSTEADY AIRFORCES FOR WINGS WITH CONTROL SURFACES PART 1. LOADING FUNCTIONS. B. L. Hewitt (British Aircraft Corp., Warton, England). 26 p. refs. (See N71-29348 17-01)

11. UNSTEADY AIRFORCES FOR WINGS WITH CONTROL SURFACES PART 2. CALCULATION METHODS. B. L. Hewitt (British Aircraft Corp., Warton, England). 24 p. refs. (See N71-29349 17-01)

12. PRESSURE MEASUREMENTS ON AN HARMONICALLY OSCILLATING SWEEP WING WITH TWO CONTROL SURFACES IN INCOMPRESSIBLE FLOW. H. Forsching, H. Triebstein, and J. Wagener (Deutsche Forschungsgemeinschaft Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, West Germany). 15 p. refs. (See N71-29350 17-01)

**N71-29339#** Vereinigte Flugtechnische Werk-Fokker GmbH, Munich (West Germany)

**SUBSONIC UNSTEADY AIRLOADS ON MULTIPLE LIFTING SURFACES**

G. Boehm and H. Schmid. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2. Apr 1971. 28 p. refs. (See N71-29338 17-01)

Avail NTIS

A survey is presented of the main features of lifting lattice methods and particularly of lifting surface methods. Ways to extend existing methods to arbitrary lifting surface configurations are also discussed. The following is a short description of these fundamentals and a detailed discussion of the numerical methods as established by the authors. Results obtained will be presented and compared with other theories. Author

**N71-29340#** Douglas Aircraft Co., Inc., Long Beach, Calif

**NEW DEVELOPMENTS AND APPLICATIONS OF THE SUBSONIC DOUBLET-LATTICE METHOD FOR NONPLANAR CONFIGURATIONS**

W. P. Rodden, J. P. Giesing, and T. P. Kalman. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2. Apr 1971. 28 p. refs. (See N71-29338 17-01)

Avail NTIS

Procedures for calculating the normalwash induced by a doublet line in nonplanar configurations and for calculating the interference between wings and bodies are given. Applications are

made to a non-coplanar wing-tail combination, a number of empennage configurations, a wing-fuselage and a wing-nacelle combination. Also considered is the calculation of velocity components in the flow field during oscillatory motion and the calculation of the distribution of induced drag in steady flow. Examples of both calculations are also presented. Author

**N71-29341#** Air Force Systems Command, Wright-Patterson AFB, Ohio: Flight Dynamics Lab  
**APPLICATION OF AFFDL UNSTEADY LOAD PREDICTION METHOD TO INTERFERING SURFACES**

W. J. Mykytow, J. J. Olsen and S. J. Pollock. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr 1971 24 p refs (See N71-29338 17-01)  
 Avail NTIS

The results of engineering applications of subsonic and supersonic lifting surface methods to some of the AGARD configurations and other interesting configurations, are presented. The subsonic kernel function program is applied to several aspects of the wing-tail interaction problem. The subsonic double lattice method is also applied to the problem. Results are also presented for a supersonic Mach box program developed for T-tails and cruciform tails along with comparisons with piston theory. Comparison between the subsonic kernel function and the doublet lattice method is generally quite good. While the double lattice method usually required greater computing times for the same accuracy as the kernel function method, it has some advantages in its favor such as ease of application and extension to more complicated configurations. The supersonic results presented here appear to be of the proper order of magnitude when compared with piston theory, however, more applications and careful checking are indicated. Author

**N71-29342#** Royal Aircraft Establishment, Farnborough (England)  
**APPLICATIONS OF UNSTEADY AIRFORCE CALCULATION METHODS TO AGARD INTERFERENCE CONFIGURATIONS**

D. E. Davies. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr 1971 18 p (See N71-29338 17-01)  
 Avail NTIS

Calculations of generalised airforce coefficients were carried out for the configurations of wing and horizontal tail and of fin and horizontal tail oscillating in subsonic flow in prescribed modes at given frequencies. Author

**N71-29343#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**MEASUREMENT OF UNSTEADY AIR LOADS OF INTERACTION BETWEEN LIFTING SURFACES IN TANDEM [MESURES DES FORCES INSTATIONNAIRES D'INTERACTION ENTRE SURFACES PORTANTES EN TANDEM]**

A. Gesteuynder. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr 1971 12 p refs. In FRENCH, ENGLISH summary (See N71-29338 17-01)  
 Avail NTIS

A series of wind tunnel tests were performed in view of analyzing the influence of several parameters on the aerodynamic interference between two lifting surfaces in tandem. The aim was to determine the magnitude of the coupling terms in order to provide a theoretical explanation of the flutter instabilities occurring on variable sweep airplanes. The tests were limited to two types of motion: pure translation and pure pitching oscillation of one wing. The model consisted of two rectangular or swept wings whose relative position could be adjusted continuously in the horizontal as well as in the vertical direction. Some comparisons between theory and experiment are given. Author

**N71-29344#** Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Munich (West Germany)

**T-TAIL AEROELASTIC ANALYSIS FOR FOKKER F.28**

J. Yff and R. J. Zwaan (Natl. Aero and Astronautical Res. Inst.) In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr 1971 15 p refs (See N71-29338 17-01)  
 Avail NTIS

Data from an aeroelastic and flutter analysis are presented. The data include lateral gust loading, aircraft designs, and mission analysis. The results indicate that mass balancing of the rudder and aileron may be deleted, testing time for high speed flutter may be reduced, and the risks of extensive modifications to the design may be reduced. The tests also achieved the certification of the aircraft. E.H.W.

**N71-29345#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)

**SOME RECENT INVESTIGATIONS ON FLUTTER IN SUBSONIC FLOW, CAUSED BY INTERFERENCE AERODYNAMIC FORCES BETWEEN WING AND TAIL OF A VARIABLE GEOMETRY AIRCRAFT**

W. Seidel and O. Sensburg. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr 1971 10 p refs (See N71-29338 17-01)  
 Avail NTIS

A method for routine flutter calculations utilizing interference aerodynamic forces between wing and tail is presented. The elastomechanic system of the aircraft is described by branch modes and the airforces for these branch modes are produced by superimposing air forces for arbitrary polynomials. The air forces are calculated for a distinct vertical offset between wing and tail with the exact kernel functions. A large variety of stiffness parameter variations was performed such as wing stiffness, fuselage stiffness and tailplane connection stiffness in order to get a better understanding of the flutter phenomenon involved and to find a cure for solving the problem. Some of the results are compared with results from wind tunnel model tests to establish the validity of the analytical method used. Author

**N71-29346#** National Aero- and Astronautical Research Inst., Amsterdam (Netherlands)

**UNSTEADY AERODYNAMICS FOR WINGS WITH CONTROL SURFACES**

H. Tijdeman and R. J. Zwaan. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr 1971 15 p refs (See N71-29338 17-01)  
 Avail NTIS

A kernel function method to calculate pressure distributions over wings with harmonically oscillating control surfaces in subsonic flow is briefly discussed. Comparisons of calculated and measured pressure distributions are given for different planforms, Mach numbers and reduced frequencies. An analysis is given of pressure distributions measured at high subsonic and transonic Mach numbers. Author

**N71-29347#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**APPLICATION OF LIFTING SURFACE THEORY TO WINGS PROVIDED WITH CONTROL SURFACES [APPLICATION DE LA THEORIE DE LA SURFACE PORTANTE A DES AILES MUNIES DE GOUVERNES]**

B. Darras and R. Dat. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr 1971 14 p refs. In FRENCH, ENGLISH summary (See N71-29338 17-01)  
 Avail NTIS

A method for solving the problem of control surfaces in subsonic unsteady flow is considered. It is based on the exploitation of the logarithmic singularity of the pressure field and on an analysis

of the usual matrix solution of the integral equation. This method, whose application to a rectangular wing has already been described, is extended here to an arbitrary planform. The comparison of experimental and theoretical results obtained for the rectangular wing is also shown. Author

**N71-29348#** British Aircraft Corp., Warton (England)  
**UNSTEADY AIRFORCES FOR WINGS WITH CONTROL SURFACES. PART 1: LOADING FUNCTIONS**  
B. L. Hewitt. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2. Apr. 1971. 26 p. refs. (See N71-29338 17-01)  
Avail. NTIS

An attempt was made, through the use of matched asymptotic expansion techniques, to define methods for finding the inner singular pressure loading functions associated with a wide variety of interaction effects on wings with unbalanced control surfaces. The work is basic in that it facilitates the construction of adequate loading forms which are necessary before attempting to obtain convergent lifting surface theory solutions. It extends the practical scope of Landahl's work and gives, as a result, sound reasons for modifying the loading recipes. Author

**N71-29349#** British Aircraft Corp., Warton (England)  
**UNSTEADY AIRFORCES FOR WINGS WITH CONTROL SURFACES. PART 2: CALCULATION METHODS**  
B. L. Hewitt. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2. Apr. 1971. 24 p. refs. (See N71-29338 17-01)  
Avail. NTIS

Using the local loading solutions, a numerical method is described which accurately evaluates the associated discontinuous downwash distribution,  $w(2)$  for steady flow.  $w(2)$  is then regularised through the specified boundary conditions to give  $w(1)$  which can then be used to gain converged solutions for the residual loading. Full loading solutions are found for rectangular wing with control surface configurations in incompressible flow, and the results compared with other methods. The form of  $w(1)$  is calculated on a simple swept wing with control surface configuration, and is found to become irregular near the hinge line corners. Modifications to the originally chosen special loading form are suggested which should lead to convergent loading solutions for swept wings. Author

**N71-29350#** Deutsche Forschungs- und Versuchsanstalt fuer Luft und Raumfahrt, Goettingen (West Germany)  
**PRESSURE MEASUREMENTS ON AN HARMONICALLY OSCILLATING SWEEP WING WITH TWO CONTROL SURFACES IN INCOMPRESSIBLE FLOW**  
H. Forscheing, H. Triebstein, and J. Wagener. In AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2. Apr. 1971. 15 p. refs. (See N71-29338 17-01)  
Avail. NTIS

The results of an experimental study of the pressure singularities occurring along the control surface edges of a harmonically oscillating swept wing control surface system in incompressible flow are presented and discussed. The two control surfaces ranged along the whole span of the wing and could be excited so that alternatively the inner or the outer flap or even both were oscillating with different phases and amplitudes relative to each other and relative to the wing. Author

**N71-31459#** Advisory Group for Aerospace Research and Development, Paris (France)  
**TECHNICAL EVALUATION REPORT ON AGARD SPECIALISTS' MEETING ON AERODYNAMIC INTERFERENCE**

David J. Peake. May 1971. 18 p. refs. Conf. held at Silver Spring, Md. 28-30 Nov. 1970.  
(AGARD-AR-34-71) Avail. NTIS

A critique of topics discussed at the AGARD meeting on aerodynamic interference is presented. Discussions evaluated include wing-body and wing-body-tail interference, airframe-propulsion interactions, and airframes-stores interference. The major advance is considered to be the treatment of a lifting wing-body combination in which a sheet of trailing vorticity from a wing was coupled with the finite element method. It is recommended that a calibration model of a wing-body combination be chosen for checking various computation schemes, and some high Reynolds number wind tunnel tests be conducted to provide details of the junction pressure distributions and the three-dimensional boundary layers and wakes. F O S

**N71-35198#** Advisory Group for Aerospace Research and Development, Paris (France). Structures and Materials Panel.  
**A COMPARISON OF METHODS USED IN LIFTING SURFACE THEORY**  
D. L. Woodcock (RAE, Farnborough, Engl.). Jun. 1971. 149 p. refs. Supplement to the Manual on Aeroelasticity. Part 6; see N65-24768  
(AGARD-R-583-71) Avail. NTIS

A joint research project, organized by the AGARD Structures and Materials Panel is reported. The purpose of the project is to establish the relative merits of different methods of calculating the air forces on oscillating wings, and to provide a standard which can be used in the future for comparison or test purposes. A scheme of cases to be considered was set up which covered variations of the parameters, planform geometry, mach number, reduced frequency and mode of oscillation. Contributions came from six countries using nearly thirty different methods and comprising nearly eight hundred calculations. The tabulated results are preceded by descriptions of the various methods used and by a comprehensive system of annotation. Author

**N71-36400#** Advisory Group for Aerospace Research and Development, Paris (France). Ad Hoc Committee  
**ENGINE-AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS**  
Aug. 1971. 143 p. refs.  
(AGARD-AR-36-71) Avail. NTIS

**CONTENTS:**  
1. CONCLUSIONS AND RECOMMENDATIONS ON ENGINE-AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS. A. Ferri. 5 p. (See N71-36401 23-01)  
2. ENGINE-AIRPLANE INTERFERENCE IN TRANSONIC TESTS. F. Jaarsma. 117 p. refs. (See N71-36402 23-01)  
3. WALL CORRECTIONS FOR AIRPLANES WITH LIFT IN TRANSONIC WIND TUNNEL TESTS. R. Monti. 15 p. refs. (See N71-36403 23-01)

**N71-36401#** Advisory Group for Aerospace Research and Development, Paris (France)  
**CONCLUSIONS AND RECOMMENDATIONS ON ENGINE-AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS**  
Antonio Ferri (New York Univ., N. Y.). In: *Eng-Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests*. Aug. 1971. 5 p. (See N71-36400 23-01)  
Avail. NTIS

The conclusions and recommendations are presented concerning the correct representation in wind tunnel tests of the interaction between engine flow and airplane characteristics, and wall interference at high lift. A review of experimental methods in use for determining engine-airplane interference in transonic tests includes the following topics: (1) inlet-airplane interference, (2) engine thrust with airplane drag and nozzle characteristics, (3) exhaust flow and airplane interference, and (4) determination of interference of the engine flow on the aerodynamic



characteristics of the complete configuration. It is concluded that all of the approaches have important unknowns and shortcomings; action is required by research groups to develop new techniques, and improve existing ones. F.O.S.

**N71-36402#** Advisory Group for Aerospace Research and Development, Paris (France).  
**ENGINE-AIRPLANE INTERFERENCE IN TRANSONIC TESTS**

F. Jarrasse (Natl. Aero- and Astronaut. Res. Inst.) *In its Eng. Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests* Aug. 1971 117 p refs (See N71-36400 23-01)

Avail. NTIS

A compilation is presented of the response to a distributed questionnaire on engine-airframe interference in transonic tests among aeronautical laboratories operating transonic wind tunnels, aircraft manufacturers, engine companies, and airplane users in the AGARD countries. The experimental techniques, correction procedures, advantages and limitations of inlet, nozzle/afterbody, complete model testing, and engine thrust determination are discussed in a technical order. Author

**N71-36403#** Advisory Group for Aerospace Research and Development, Paris (France).  
**WALL CORRECTIONS FOR AIRPLANES WITH LIFT IN TRANSONIC WIND TUNNEL TESTS**

R. Monti (Univ. Degli Studi, Naples, Italy) *In its Eng. Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests* Aug. 1971 15 p refs (See N71-36400 23-01)

Avail. NTIS

The technical information supplied by the Ad Hoc Committee is summarized. After some preliminary remarks on wall interference corrections in transonic tests, the different answers to the AGARD questionnaire are presented together with the main points made by the committee members as representatives of the different countries. A number of general agreements among the committee members are stated which indicate the state-of-the-art of transonic wind tunnel corrections. The discussions and the conclusions of the committee are presented on the problems which appear to be most important for future research. Problems are briefly reviewed and research areas are indicated for which the committee agreed an international program will be most profitable. A list of references is provided which includes the works referenced by all the different groups participating in the committee. Author

**N72-11854#** Advisory Group for Aerospace Research and Development, Paris (France).  
**FACILITIES AND TECHNIQUES FOR AERODYNAMIC TESTING AT TRANSONIC SPEEDS AND HIGH REYNOLDS NUMBER**

Aug. 1971 409 p refs. Presented at the Fluid Dyn. Panel Specialists Meeting, Goettingen, 26-28 Apr. 1971 (AGARD-CP-83-71) Avail. NTIS HC \$6.00/MF \$0.95

Theoretical methods and wind tunnel facilities for transonic aerodynamic testing of aircraft at high Reynolds numbers are outlined. Requirements of test facilities are clarified and possible improvements in existing facilities and testing techniques are discussed. For individual titles, see N72-11855 through N72-11887.

**N72-11855#** Royal Aircraft Establishment, Farnborough (England).  
**SCALE EFFECTS IN FLOWS OVER SWEEPED WINGS**

M. G. Hall *In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number* Aug. 1971 22 p refs (See N72-11854 03-01)

Avail. NTIS HC \$6.00/MF \$0.95

A review is given of the effects of variations in Reynolds number on the possible types of flow over a swept wing and the boundaries between them. Three main flow regimes are discussed in turn: the attached boundary layer which may be laminar or

turbulent and where the position of transition is important, the thin wake which extends downstream from the trailing edge of the wing, and the regime of separated flow. Their interactions with the external flow and with each other are included. The flow structures are three dimensional in general. Reynolds number effects are best understood where simple extensions from two dimensions can be made. The most serious gaps in understanding are found where compressibility and strong interactions are important. Author

**N72-11856#** Royal Aircraft Establishment, Bedford (England).  
**SOME ASPECTS OF VISCOUS INVISCID INTERACTIONS AT TRANSONIC SPEEDS, AND THEIR DEPENDENCE ON REYNOLDS NUMBER**

J. E. Green *In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number* Aug. 1971 12 p refs (See N72-11854 03-01)

Avail. NTIS HC \$6.00/MF \$0.95

Current understanding of viscous-inviscid interactions is reviewed, with particular reference given to the characteristics of interactions on transonic swept wings and their dependence upon Reynolds number. Interactions of three different degrees are discussed: the weak interaction between boundary layer and wake development overall and the flow field at large, the strong but localized interaction beneath shockwaves and at trailing edges in fully attached flow, and the strong interactions which involve boundary layer separation and hence have an important effect on the entire flow field. Finally, the possibilities are discussed of manipulating the boundary layer in order to simulate, in the wind tunnel, the viscous-inviscid interactions found at flight Reynolds numbers. Author

**N72-11857#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).  
**A METHOD FOR CALCULATING THE TRANSONIC BUFFET BOUNDARY INCLUDING THE INFLUENCE OF REYNOLDS NUMBER**

F. Thomas and G. Redeker *In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number* Aug. 1971 14 p refs (See N72-11854 03-01)

Avail. NTIS HC \$6.00/MF \$0.95

A purely theoretical method for calculating the buffet boundary of straight and swept wings including the effects of Reynolds numbers is reported. In the procedure of calculation, Sinnott's method for estimating the pressure distribution in a transonic flow with shock waves is used, as well as the methods of Walz and Cumpsty and Head for calculating turbulent boundary layers in two- and three-dimensional compressible flow. The agreement of the theoretical calculation with experimental results from wind tunnel and flight tests at various Reynolds numbers is very satisfactory. Author

**N72-11858#** Royal Aircraft Establishment, Farnborough (England) Aerodynamics Dept.  
**A TYPE OF STALL WITH LEADING EDGE TRANSONIC FLOW AND REAR SEPARATION**

J. Osborne and H. H. Pearcey *In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number* Aug. 1971 11 p refs (See N72-11854 03-01)

Avail. NTIS HC \$6.00/MF \$0.95

Surface pressure measurements are presented for a leading edge, transonic flow which occurs for high angles of incidence and for stream speeds in the medium subsonic range. A shock induced separation develops in the first 5% of the chord, and also present is the rear separation that would be expected in the low speed stall of an aerofoil having a thickness/chord ratio greater than about 10%. Results for transition fixed and free reproduce respectively the classical features for turbulent and laminar type interactions at the leading edge shock, these leave different disturbances in the reattached turbulent layer which then react differently on the rear separation. A few results are included for an intermediate effect on transition. The Reynolds number for all the tests was in the region of  $2 \times 10^6$  million based on aerofoil chord. Author

**N72-11859# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va**  
**REYNOLDS NUMBER REQUIREMENTS FOR VALID TESTING AT TRANSONIC SPEEDS**

William B Iggoe and Donald E Basile /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 5 p refs (See N72-11854 03-01)

(NASA-TM-X-67412) Avail NTIS HC \$6 00/MF \$0 95 CSCI 200

The variation of wing shock location with Reynolds number has been examined for configurations for which both flight and wind tunnel wing pressure distribution data were available to determine if there is a minimum level of Reynolds numbers, short of full scale, at which reliable flow simulation can be achieved in transonic test facilities. The shock locations as a function of Reynolds numbers at conditions of constant Mach number and angle of attack were normalized so that shock position was obtained in relative terms from zero to unity for each configuration and condition studied. Normalizing the shock location permitted the comparison of data for different configurations and conditions on a common basis. Not enough data have been analyzed thus far to obtain conclusive results.

Author

**N72-11860# Northrop Corp., Hawthorne, Calif. Aircraft Div**  
**RECENT EXPERIENCE IN THE TRANSONIC TESTING OF TWO DIMENSIONAL SWEEP AND STRAIGHT WINGS WITH HIGH LIFT DEVICES**

W E Grahame, J W Headley, and L W Rogers /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 17 p refs (See N72-11854 03-01)

Avail NTIS HC \$6 00/MF \$0 95

The results of a series of transonic tests of two dimensional wings with various high lift devices are presented. The tests were performed in an aerodynamic transonic wind tunnel on an unswept wing with a jet flap and a swept wing with boundary control devices. Both wings were tested through a Mach range of  $M = 0.70$  to  $M = 0.95$  and a Reynolds Numbers range of 2.5 to 5.5 million per foot. Additional tests included a supercritical wing with slot blowing and a leading edge flap with a jet flap. Comparisons of wing pressure distributions and flow visualization studies illustrate the effectiveness of the jet flap and also the high lift devices in controlling flow separation. Longitudinal characteristics which show the effects of Reynolds number are also presented. Comparative analyses indicating the improvement obtained with each of the high lift devices is shown.

Author

**N72-11861# National Aeronautical Establishment, Ottawa (Ontario)**

**THE TRANSONIC PERFORMANCE OF TWO DIMENSIONAL JET FLAPPED AEROFOILS AT HIGH REYNOLDS NUMBERS**

D J Peeke, H Yoshihara, D Zonars, and W Carter /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 39 p refs (See N72-11854 03-01)

Avail NTIS HC \$6 00/MF \$0 95

Tests in the transonic wind tunnel were conducted to determine the effect of Reynolds numbers on the transonic performance of a 10% air cambered profile with jet flaps - in particular the effect on the pressure distribution, drag divergence, and buffet onset. Distributed suction was applied on the sidewalls in the vicinity of the model to insure that the interaction of the shock was primarily with the airfoil boundary layer. The absence of sidewall suction had a significant effect upon the upper surface flow, with the shock being displaced upstream by about 15% of the chord. In the range of the Reynolds number tested, there was a noticeable effect of Reynolds number on drag divergence and a significant effect on buffet onset.

Author

**N72-11862# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)**

**EXPERIMENTAL INVESTIGATION OF THE DRAG OF WINGS WITH A BLUNT TRAILING EDGE AT TRANSONIC SPEEDS**

M Tanner /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 6 p refs (See N72-11854 03-01)

Avail NTIS HC \$6 00/MF \$0 95

The possible improvement of aerodynamic profiles due to blunt trailing edges, drag and lift measurements was studied on two wings of finite span in a transonic wind tunnel. The Mach number had values from 0.5 to 2.2 and the Reynolds number was about  $Re = 1,500,000$ . From these results it was possible to conclude that in order to achieve a drag reduction at transonic speeds the trailing edge thickness should not be excessive and the boattailing angle should be small. Furthermore, a special broken shape of the trailing edge is favorable for low drag at these Mach numbers. At supersonic speeds the attainable drag reduction at zero lift is greater than predicted by Chapman. The lift curve slope is greater for the wing with a blunt trailing edge than for the wing with a conventional sharp trailing edge. With the most efficient blunt trailing edge the maximum lift to drag ratio at transonic speeds is only a few per cent lower than for the wing with a sharp trailing edge.

Author

**N72-11863# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)**

**FORCE AND PRESSURE MEASUREMENTS ON A SLENDER DELTA WING AT TRANSONIC SPEEDS AND VARYING REYNOLDS NUMBERS**

W Stahl, K Hartmann, and W Schneider /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 11 p refs (See N72-11854 03-01)

Avail NTIS HC \$6 00/MF \$0 95

Transonic wind tunnel investigations were carried out on a slender delta wing with aspect ratio  $A = 0.52$  at Mach numbers 0.5, 0.7, 0.8, 0.9, 0.95, 0.975, 1.0, 1.1, and 1.2 for angles of incidence up to about 30 deg. Normal force and pitching moments were measured as well as spanwise pressure distributions on the wing's pressure and suction side at five cross sections. The Reynolds number was held constant at a value of  $Re = 2,700,000$  for all Mach numbers. The normal force and pitching moment coefficients showed a noticeable dependence on Reynolds number, the pressure distribution was influenced mainly around the suction peak. Successful attempts were made at low Reynolds number to influence the boundary layer on the wing's suction side by means of a carbonium band. Insight was obtained into the structure of the flow field, near sonic velocities, by using a newly developed smoke visualization technique and with the help of oil flow pictures.

Author

**N72-11864# Army Missile Command, Huntsville, Ala**  
**BODIES OF REVOLUTION AT TRANSONIC SPEEDS: THE ESTIMATION OF REYNOLDS NUMBER EFFECTS**

T H Moulden, D J Spring, R O Sassi, K Aoyama, and J M Wu /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 13 p refs (See N72-11854 03-01)

Avail NTIS HC \$6 00/MF \$0 95

The experimental data presented are taken from a series of tests on a body of revolution at transonic speeds. The test Reynolds number was of the order of one million. Both mounting strut and tunnel wall interference effects are discussed. A theoretical procedure is developed to take account of the viscous effect on the body. It is shown that the potential flow theory of Wu and Aoyama gives close agreement with experimental data. However, and particularly to study separation and Reynolds number effects, it is necessary to introduce boundary layer effects in the theoretical work. Taking the displacement surface as an equivalent body for the second approximation, it is shown that only a small change in surface pressure distribution on the body is realized. Hence, it follows that in the absence of separation a large change in Reynolds number is of little

significance as far as surface pressures are concerned. The general conclusion is that for a body of revolution, tunnel and mounting interference effects are more significant than Reynolds number effects, provided the flow is not separated. Author

**N72-11865#** Grumman Aerospace Corp. Bethpage, N.Y.  
**TRANSONIC AERODYNAMIC CHARACTERISTICS AND THEIR EVALUATION**

Arthur A. Lambert. In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number. Aug. 1971. 4 p. refs. (See N72-11854 03-01)  
Avail. NTIS HC \$6.00/MF \$0.95

The need for more systematic transonic wind tunnel testing to spin down the effects of flow and environment combinations and to establish a more scientific basis for flight simulation and analysis is outlined. The discussion includes the effects of steady, unsteady, and mixed flow phenomena on tools used for design and evaluation of the important transonic flight performance parameters of modern aircraft, i.e., max. g capability, maneuvering buffet, level flight buffet, control problems, and peak drag characteristics. The design tools include trailing edge angle criteria, the effect of various sweep lines and wing leading edge development. Wind tunnel evaluation tools include isobar contours, pressure taps, accelerometers, tilt stands, and oil flow techniques. The effects of scale and Reynolds Number in connection with various flow phenomena and associated flight conditions are also discussed. Author

**N72-11866#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**TRANSONIC TESTING OF THE ENGINE NACELLE AIR INTAKE AND AFTERBODY [ENTRÉE D'AIR ET ARRIÈRE CORPS DE FUSEAU MOTEUR EN TRANSSONIQUE]**

J. Leynaert. In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number. Aug. 1971. 10 p. refs. In FRENCH. ENGLISH summary. (See N72-11854 03-01)

Avail. NTIS HC \$6.00/MF \$0.95

An example is presented of the study of a double-flux engine nacelle at high subsonic Mach numbers, the investigation being made at high Reynolds numbers with two separate models for the air intake and the afterbody. The test on the afterbody shows that the conditions of variable jets do not react significantly on the upstream flow around the nacelle intake and cowl, apart from the immediate vicinity of the exhaust; this fact justifies the large scale study of the air intake with a model supported downstream by a cylindrical tube replacing the jet. In the same way, mass-flow rate variations of the air intake do not react on the flow around the afterbody; in a given margin, this allows the study of the afterbody on an upstream sting. Author

**N72-11867#** Aircraft Research Association, Ltd., Bedford (England)

**POSSIBILITIES FOR SCALE EFFECT ON SWEEP WINGS AT HIGH SUBSONIC SPEEDS: RECENT EVIDENCE FROM PRESSURE PLOTTING TESTS**

A. B. Haines. In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number. Aug. 1971. 11 p. refs. (See N72-11854 03-01)  
Avail. NTIS HC \$6.00/MF \$0.95

The possibilities for scale effect on swept wings under supercritical flow conditions at high subsonic speeds are discussed on the basis of evidence from pressure plotting tests on a variety of wings. For the Super VC 10, comparison of pressure distributions measured in flight and in model tests at  $R = 5.4 \times 10^6$  shows some scale effect. For other designs however, the scale effect could be much greater; the paper shows that the underfixing technique has limitations when applied to a sweptback wing. Examples are included where the flow patterns are very complex with many interacting features; in such cases it is often difficult even to forecast whether the scale effect is favourable or unfavourable. Further improvements in swept wing design will increase the likelihood of serious scale effect. Author

**N72-11868#** Aeronautical Research Inst. of Sweden, Stockholm  
**CORRELATION OF SOME TRANSONIC WIND TUNNEL TEST DATA TO FLIGHT TEST RESULTS FOR TWO SLENDER WING AIRPLANES**

Sven Erik Nyberg. In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number. Aug. 1971. 10 p. (See N72-11854 03-01)  
Avail. NTIS HC \$6.00/MF \$0.95

Some of the flight test data obtained on two slender wing airplanes have been correlated to transonic wind tunnel test data obtained with 1/30 and 1/50 scale models. Static stability and control derivatives as well as damping and period in pitch and Dutch roll oscillations as predicted by the wind tunnel tests show good agreement with flight tests. The predicted zero lift drag for one of the airplanes was higher than the flight test drag whereas the agreement in lift induced drag was satisfactory. Predicted component loadings have been found to agree well with flight test results. Air inlet pressure recovery was slightly higher in flight than in the wind tunnel. Flow distortion at engine face shows good correlation even at high angles of attack. It is concluded from these results that for slender wing configuration, transonic wind tunnel test data are in general reliable, even if obtained at relatively low Reynolds number. Author

**N72-11869#** National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif.

**A COMPARISON OF SOME AERODYNAMIC DRAG FACTORS AS DETERMINED IN FULL SCALE FLIGHT WITH WIND-TUNNEL AND THEORETICAL RESULTS**

Edwin J. Saltzman and Donald R. Bellman. In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number. Aug. 1971. 22 p. refs. (See N72-11854 03-01)

(NASA-TM-X-67413) Avail. NTIS HC \$6.00/MF \$0.95  
CSCL 20D

Reliable techniques for defining flight values of overall aircraft drag and turbulent skin friction, and the drag associated with local regions of separated flow are reported. Selected results from these studies are presented for several types of aircraft, including the X-15, the XB-70, lifting bodies, and military interceptors. These flight results are compared with predictions derived from windtunnel models or, for friction, with the Kármán-Schoenherr relationship. The flight experiments have defined the turbulent skin friction to Reynolds numbers somewhat above  $10^6$  to the 8th power, the overall drag of two airplanes, base pressure coefficients for aircraft and for an aft-facing step immersed in a thick boundary layer. A flight application of a splitter plate for reducing base drag is discussed along with examples of the drag associated with afterbody flow separation for shapes having relatively large afterbody closure angles. Author

**N72-11870#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**FEASIBILITY OF TESTING A LARGE-CHORD, SWEEP-PANEL MODEL TO DETERMINE WING SHOCK LOCATION AT FLIGHT REYNOLDS NUMBER**

Jones F. Cahill (Lockheed-Georgia Co.), Stuart L. Treon, and William R. Holstetter. In AGARD Facilities and Tech. for Aerodyn. Testing at Transonic Speeds and High Reynolds Number. Aug. 1971. 11 p. refs. (See N72-11854 03-01)  
(L. Contracts F33615-69-C01256, F33615-67-C-1777)

(NASA-TM-X-67414) Avail. NTIS HC \$6.00/MF \$0.95  
CSCL 20D

As a part of a study of methods for simulating high Reynolds number aerodynamic characteristics of large aircraft, tests have been conducted in an 11 foot transonic wind tunnel to determine the feasibility of using a large chord wind panel model to investigate the variation of shock location with Reynolds number. The model was untwisted and was of constant chord and thickness. The airfoil section was that from one station on the span of a high speed transport airplane for which a substantial amount of flight and wind tunnel pressure distribution data had previously been obtained at widely different Reynolds numbers with indications of a large scale effect on

shock location. The major findings from this study were that the variation of shock location on the panel model was identical in character, but considerably smaller over the Reynolds number range from 8.8 million to 28.0 million than that indicated by existing data on the complete wing. Generally, the panel model data on shock location and trailing-edge pressure recovery tended toward better agreement with flight data than with previous wind tunnel data on smaller complete models. Author

**N72-11971#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)  
**WIND TUNNEL QUALIFICATION BY PERFORMANCE PREDICTION AND FLIGHT VERIFICATION (VALIDITE DE LA SOUFFLERIE POUR LA PREVISION DES PERFORMANCES ET DES QUALITES DE VOL)**

Ph. Poisson-Quinton. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number. Aug 1971. 16 p. refs. In FRENCH (See N72-11854 03-01)

Avail NTIS HC \$6.00/MF \$0.95

Summaries of brief data sheets are presented that contain information on new analytical prediction methods and flight tests for the development of transonic wind tunnels. Points of agreement as well as of disagreement are illustrated to stimulate new research for improving wind tunnel qualities. Author

**N72-11872#** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.  
**TRANSONIC TESTING IN EXISTING WIND TUNNELS**

J. Lloyd Jones. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number. Aug 1971. 8 p. refs. (See N72-11854 03-01)  
(NASA-TM-X-67415) Avail NTIS HC \$6.00/MF \$0.95  
CSC 148

The problems of obtaining representative transonic aerodynamic data in existing wind tunnels are examined. The problems are approached by reviewing those factors which influence the accuracy of measurement and flow simulation. Examples of flow simulation anomalies are given. Demands for increased accuracy and requirements for conducting transonic investigations under conditions increasingly more susceptible to simulation anomalies are cited. Author

**N72-11873#** Lockheed-Georgia Co., Marietta  
**SIMULATION OF FULL SCALE FLIGHT AERODYNAMIC CHARACTERISTICS BY TESTS IN EXISTING TRANSONIC WIND TUNNELS**

Jones F. Cahill. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number. Aug 1971. 8 p. refs. (See N72-11854 03-01)  
Avail NTIS HC \$6.00/MF \$0.95

Although newly evolving concepts will enable the construction of relatively inexpensive wind tunnels capable of producing transonic aerodynamic data at flight Reynolds numbers, a substantial portion of future aircraft development testing will be done at subscale conditions. It is imperative, therefore, that methods be developed for accurate simulation of flight aerodynamic characteristics during tests at low Reynolds numbers. Several concepts for high Reynolds number simulation have been advanced, and some have been demonstrated for isolated cases. Some of these concepts are reviewed in the light of existing data. Author

**N72-11874#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)  
**SIMULATION OF TWO DIMENSIONAL AEROFOIL FLOW AT HIGH SUBSONIC MACH NUMBERS AND HIGH REYNOLDS NUMBERS BY MEANS OF AN EQUIVALENT BODY OF REVOLUTION**

W. Lorenz-Mayer. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number. Aug

1971. 8 p. refs. (See N72-11854 03-01)

Avail NTIS HC \$6.00/MF \$0.95

In order to study the effect of high Reynolds numbers on the transonic flow past two-dimensional aerofoils, an equivalent body of revolution was constructed, having a four to five times larger chord size than the corresponding aerofoil, and giving the same rate of tunnel blockage. The contour of the body was calculated by means of a source-sink distribution. Force and pressure measurements have been performed in a transonic tunnel at Mach numbers from 0.5 to 0.925 and Reynolds numbers from  $Re_{sub L} = 4$  million to 16 million. In the subcritical range the results show good agreement with the calculated first-order potential flow. The evaluation of minimum pressure coefficient and shock position show that from  $Re_{sub L} = 8$  million no significant dependence on Reynolds number exists either at subcritical or supercritical speeds. Author

**N72-11875#** Hawker Siddeley Aviation, Ltd., Kingston upon Thames (England)

**ON THE POSSIBILITY OF DEDUCING HIGH REYNOLDS NUMBER CHARACTERISTICS USING BOUNDARY LAYER SUCTION**

Cliff L. Bore. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number. Aug 1971. 10 p. refs. (See N72-11854 03-01)

Avail NTIS HC \$6.00/MF \$0.95

It seems that the most crucial differences of characteristics from wind tunnel models to full scale aircraft stem from the fact that the boundary layers on the model are usually relatively too thick. Consequently it has been suggested that full-scale behaviour may be more accurately simulated if the thickness of the boundary were reduced appropriately by means of suction through porous strips in the surface of the models. A suitable technique would afford convenient means for varying the boundary layer thickness without stopping the wind tunnel, and should be applicable to more model configurations than conventional underfixing of transition. The implications of these propositions are examined in the light of boundary layer calculations and data. Author

**N72-11876#** London Univ. (England)

**SOUND FIELDS GENERATED BY TRANSONIC FLOWS OVER SURFACES HAVING CIRCULAR PERFORATIONS**

M. M. Freestone and R. N. Cox. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number. Aug 1971. 8 p. refs. (See N72-11854 03-01)

Avail NTIS HC \$6.00/MF \$0.95

Tests made on the sound waves radiated from perforated transonic tunnel liners having perpendicularly drilled holes have shown that a regular pattern of coherent wave fronts occurs. It is suggested that the coupling is caused by a disturbance propagating along the surface of the liner. Results from individual holes indicate that the mechanism for production of sound waves is similar to that observed from two dimensional cavities, and that the Strouhal numbers of the modes occurring can be predicted with reasonable accuracy for both normal and inclined holes using a model proposed by Rossiter. Author

**N72-11877#** New York Univ., N.Y.

**ENGINE AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS**

Antonio Ferri. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number. Aug 1971. 6 p. (See N72-11854 03-01)

Avail NTIS HC \$6.00/MF \$0.95

Recent developments of high performance airplanes have generated requirements for the prediction of the aerodynamic performance of airplane designs with extremely high accuracy. A critical review of present experimental methods led to the initiation of two separate efforts related to experiments in transonic flows: (1) determination of Reynolds number effects

and the design of high Reynolds number wind tunnels, and (2) correct representation in wind tunnel tests of the interaction between engine flow and airplane characteristics, and wall interference at high lift. Author

**N72-11878\*** National Aeronautics and Space Administration Langley Research Center, Langley Station, Va  
**TRANSONIC FREE-FLIGHT MODEL TESTING AT LARGE SCALE**

Clarence L. Gillis. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 9 p refs (See N72-11854 03-01)  
(NASA-TM-X-67416) Avail NTIS HC \$6.00/MF \$0.95 CSCL 200

The use of free flight models for transonic testing at high Reynolds numbers is discussed. Several specific examples of experimental investigations are briefly reviewed to illustrate the scope of research that can be conducted by utilizing the advantages of free flight models. These advantages are primarily the lack of interference or constraints imposed by test facilities and model support systems and the dynamic freedom possessed by free flight models. High Reynolds numbers are obtained by using large models flown at relatively low altitudes. It is shown that models 10 meters or more in length will be required for research at Reynolds numbers sufficiently high to provide representative simulation of flow conditions for large modern aircraft. Several methods for launching models of this size are discussed. These methods include free drops from airplanes or balloons and ground launches with the use of internal or external rocket motors. All the launching methods discussed have been successfully demonstrated on flight vehicles of the size and weight required to attain the necessary test conditions. Author

**N72-11879\*** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif  
**ON THE USE OF FREON-12 FOR INCREASING REYNOLDS NUMBER IN WIND-TUNNEL TESTING OF THREE DIMENSIONAL AIRCRAFT MODELS AT SUBCRITICAL AND SUPERCRITICAL MACH NUMBERS**

Stuart L. Treon, William R. Hofstetter, and Frank T. Abbott. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 8 p refs (See N72-11854 03-01)  
(NASA-TM-X-67417) Avail NTIS HC \$6.00/MF \$0.95 CSCL 148

The aerodynamic suitability of Freon-12 for general wind-tunnel testing was investigated at low and high subsonic speeds. Static aerodynamic characteristics of two transport airplane models were determined from strain gage balance measurements in both air and Freon-12 at several Reynolds numbers. A low-speed high-lift configuration was evaluated at Mach number 0.25, and a high-speed cruise wing-fuselage combination was tested at Mach numbers up to 0.825. The data obtained in air and in Freon-12 agree well, even in stalled flow, until compressibility effects evidently become significant in air and in Freon-12 agree well, even in stalled flow, until compressibility effects evidently become significant in air. Author

**N72-11880\*** National Aeronautics and Space Administration Langley Research Center, Langley Station, Va  
**A FACILITY CONCEPT FOR HIGH REYNOLDS NUMBER TESTING AT TRANSONIC SPEEDS**

Donald D. Baals and George M. Stokes. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 12 p refs (See N72-11854 03-01)  
(NASA-TM-X-67418) Avail NTIS HC \$6.00/MF \$0.95 CSCL 148

The critical need for high Reynolds number experimental capability at transonic speeds has been broadly recognized, because there have been demonstrated significant transonic scale effects on wing-shock position with related effects on drag-rise Mach number, buffet boundary, and pitching-moment

characteristics. Of the various ground-based transonic facilities considered for provision of high Reynolds number capability, the conventional wind tunnel operated in a semicontinuous mode and utilizing an energy storage system is considered to have the greatest potential. A hydropumped-storage system is proposed to provide hydraulic energy on an intermittent schedule at the rate of 500,000 horsepower to propel hydraulic turbines directly coupled to the wind-tunnel fans. Author

**N72-11881\*** ARO, Inc., Arnold Air Force Station, Tenn. Von Karman Gas Dynamics Facility  
**HIGH REYNOLDS NUMBER TRANSONIC WIND TUNNELS: BLOWDOWN OR LUDWIG TUBE?**

Jack D. Whitfield, C. J. Schueler, and Rogers F. Starr. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 17 p refs (See N72-11854 03-01)  
(Contract F40600-71-C-0002)  
Avail NTIS HC \$6.00/MF \$0.95

The results are given of a detailed comparison between a conventional blowdown transonic wind tunnel and a Ludwig tube driven transonic wind tunnel, both designed to cover the same Mach-Reynolds number regime. It is concluded that the Ludwig tube driven tunnel will provide superior flow at a significantly lower cost. The data production capabilities of a Ludwig tube driven tunnel, with appropriate design features, were surprisingly high. The production capability of the Ludwig tube exceeds the conventional blowdown tunnel at very high Reynolds numbers and compares favorably with existing transonic tunnels at intermediate Reynolds numbers. Experimental results from a small Ludwig tube driven transonic research tunnel are presented and discussed. The research tunnel is equipped with variable porosity test section walls and an independently controlled plenum exhaust. Both static and dynamic pressure measurements are presented in preliminary form. Author

**N72-11882\*** National Aeronautics and Space Administration Marshall Space Flight Center, Huntsville, Ala  
**MSFC HIGH REYNOLDS NUMBER TUBE TUNNEL**

A. Richard Felix. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 10 p refs (See N72-11854 03-01)  
(NASA-TM-X-67419) Avail NTIS HC \$6.00/MF \$0.95 CSCL 148

A high Reynolds number tube tunnel is described and illustrated by drawings and photographs. Its mode of operation and performance characteristics are also described. This impulse-type tunnel has a test section diameter of 32 inches and a Mach number range from 0.2 to 2.0. The transonic test section is equipped with a variable porosity perforated wall. A maximum unit Reynolds number of 200 million per foot is produced at a Mach number of 1.3 and the maximum tunnel charge pressure of 700 psig. The useful test time is 150 milliseconds or more at all operating conditions. Some typical test section calibration results are included. Author

**N72-11883\*** Royal Aircraft Establishment, Farnborough (England)

**SOME FACTORS RELEVANT TO THE SIMULATION OF FULL SCALE FLOWS IN MODEL TESTS AND TO THE SPECIFICATION OF NEW HIGH REYNOLDS NUMBER TRANSONIC TUNNELS**

J. Y. G. Evans and C. R. Taylor. In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 13 p refs (See N72-11854 03-01)  
Avail NTIS HC \$6.00/MF \$0.95

Limitations and difficulties of achieving representative flow simulation in model tests are considered. Particular attention is given to obtaining design data for swept-winged aircraft at high lift coefficients, when the flow over the wing is locally transonic and sensitive to scale. Examination of the limitations due to model strength suggests that the maximum tunnel static pressure for tests at high lift conditions is about 5 atm, and consequently

that full scale Reynolds number could only be obtained in very large tunnels. Author

**N72-11884#** Advisory Group for Aerospace Research and Development, Paris (France).

**AGARD STUDY OF HIGH REYNOLDS NUMBER WIND TUNNEL REQUIREMENTS FOR THE NORTH ATLANTIC TREATY ORGANIZATION NATIONS**

Robert O Dietz /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 9 p (See N72-11854 03-01)

Avail: NTIS HC \$6 00/MF \$0 95

Performance and operating characteristics required in two new, high Reynolds number wind tunnels are defined, and conceptual tunnel designs which meet these requirements are given. One tunnel of the Ludwig tube type should duplicate transonic flight Reynolds numbers and have a run time of about one second. The second, a blowdown type wind tunnel, should provide Reynolds numbers that are three or four times the maximum presently available and have a run time of about ten seconds. Author

**N72-11885#** Air Force Special Weapons Center, Holloman AFB, N.Mex.

**HIGH REYNOLDS NUMBER TESTING BY MEANS OF ROCKET SLEDS**

Hans J Rasmussen /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 8 p refs (See N72-11854 03-01)

Avail: NTIS HC \$6 00/MF \$0 95

Most aerodynamic ground testing is conducted in facilities which move air under controlled conditions over ground-fixed test models. This paper invites attention to the opposite approach. Aerodynamic ground testing by moving test specimen through ambient air along a rigorously defined straight line path by means of rocket sleds is reported. Some basic technical facets of rocket sled testing are reviewed and characteristics as well as current capabilities of this technique are discussed with emphasis on aerodynamic and structural design of the test vehicles, on typical test trajectories, and on electronic and photo-optical data acquisition. Similitude considerations governing aerodynamic testing by this technique are discussed and typical examples of past, current, and planned test activities in this area are reviewed. Concluding merits and limitations of this technique as compared to other ground test approaches and to flight tests are outlined. Author

**N72-11886#** Dornier-Werke GmbH, Friedrichshafen (West Germany).

**WIND TUNNEL INVESTIGATION OF BUFFET LOADS ON FOUR AIRPLANE MODELS**

R. Vanino and E. Wedemeyer /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 15 p refs (See N72-11854 03-01)

Avail: NTIS HC \$6 00/MF \$0 95

Buffet loads and buffet boundaries have been investigated in a transonic wind tunnel by measurements of bending moments at the wing roots for high subsonic Mach numbers. These tests were carried out for four airplane models having wings of different thicknesses and aspect ratios and also different angles of sweep. Simultaneous observation of oil flow patterns provided the means to study the relation between flow separation and buffeting. The test Reynolds numbers ranged from  $Re = 1$  million to 2 million. Securing turbulent boundary layer at the shock position by means of artificial transition, no effect of Reynolds number of buffet boundaries was observed. For the models tested it was found that low sweep and low aspect ratio yield favorable buffet boundaries. Author

**N72-11887#** Royal Aircraft Establishment, Farnborough (England).

**A SCHEME FOR A QUIET TRANSONIC FLOW SUITABLE**

**FOR MODEL TESTING AT HIGH REYNOLDS NUMBER**

J. Y. G. Evans /In AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 5 p refs (See N72-11854 03-01)

Avail: NTIS HC \$6 00/MF \$0 95

A wind tunnel suitable for future research and development towards better transonic aircraft should be able to achieve a Reynolds number, based on the mean chord of a typical swept-winged aircraft, of at least 40 million. Practical limits to model strength and stiffness dictate stagnation pressures below 7 atmospheres and consequently the test section must be at least 5 m in width. For this duty, a new type of facility is proposed, which combines the good driving efficiency of the continuous tunnel with the stored-energy advantage of intermittent running. Of particular importance, the tunnel would be relatively quiet to operate and should provide an extremely clean and steady flow. Author

**N72-12978#** Advisory Group for Aerospace Research and Development, Paris (France).

**AERODYNAMIC TESTING AT HIGH REYNOLDS NUMBERS AND TRANSONIC SPEEDS**

D. Kuechemann (Roy. Aircraft Estab., Farnborough, Engl.) Nov. 1971 9 p refs. Presented at NATO Defence Res. Group Seminar on Gen. Probl. Relating to Aerodyn. Testing Facilities, St. Louis, France, 4-7 May 1971.

(AGARD-R-588-71) Avail: NTIS

As a contribution to a NATO seminar on aerodynamic testing facilities held at the ISL from 4 to 7 May 1971, a brief report is given on the outcome of a specialists' meeting organized by the fluid dynamics panel of AGARD and held at Gottingen from 26 to 28 April 1971. Various AGARD activities, leading up to this meeting, are also briefly described. The best technical advice available within AGARD leads to the conclusion that one or several large new wind tunnels would contribute immensely to the effectiveness of a large number of aerospace systems now planned or contemplated within the NATO nations. Author

**N72-22001#** Advisory Group for Aerospace Research and Development, Paris (France).

**SOME RECENT DEVELOPMENTS IN PLANAR INVISCID TRANSONIC AIRFOIL THEORY**

H. Yoshihara (Gen. Dyn./Convair, San Diego, Calif.) Feb. 1972 38 p refs.

(AGARD-AG-156; AGARD; graph-156) Avail: NTIS

Some recent efforts to calculate planar inviscid supercritical flow over airfoils are reviewed giving typical results achieved. The hodograph procedures of Nieuwland and Boerstoel, and Garabedian and Korn are first reviewed which yield shockless profiles. The unsteady finite difference procedure of Mannus and Yoshihara is then described and its use then illustrated by several lifting examples with shocks. This is then followed by a description of two steady procedures. The first is that of Murman and Cole, who used a line relaxation procedure to solve a boundary value problem composed of the transonic perturbation equations with planar boundary conditions. The second is the procedure of Steger and Lomax who used the exact equations, and quasi-planar boundary conditions, and the finite difference relaxation procedure of Murman and Cole. The review is concluded by making a brief assessment of the various methods. Author

**N73-14000#** Advisory Group for Aerospace Research and Development, Paris (France).

**UNSTEADY AERODYNAMICS OF HELICOPTER ROTORS**

Oct. 1972 50 p refs. Partly in ENGLISH, partly in FRENCH. Presented at 34th AGARD Struct. and Mater. Panel Meeting, Lyngby, Denmark, 11 Apr. 1972.

(AGARD-R-595) Avail: NTIS HC \$4 50

The proceedings of a conference on the unsteady aerodynamics of helicopter rotors are presented. Methods for improving the analytical prediction methods for assessing loads, loads, both

static and dynamic, exerted on rotor blades are discussed. Test data to evaluate the effectiveness of current analytical design procedures are correlated with analytical methods. Modifications of design procedures for design of future aircraft are examined. For individual titles, see N73-14001 through N73-14003.

**N73-14001** Texas A&M Univ., College Station. Dept. of Aerospace Engineering Dept.

**UNSTEADY AERODYNAMICS OF HELICOPTER ROTORS**  
W. P. Jones. In AGARD Unsteady Aerodyn. of Helicopter Rotors. Oct. 1972. 23 p. refs. (For availability see N73-14000 05-01) (Grant DA-ARO(D)-31-124-71-G153)

Developments in the field of research on unsteady aerodynamics of helicopter rotors are presented. Advances in such problem areas as stall flutter of a retreating rotor blade, flutter of the advancing blade, transient effects due to the interaction of the tip-vortex of one blade with a following blade and wake induced instabilities in hovering and low speed flight are discussed. Attention is also drawn to aspects requiring additional research and, where possible, suggestions are made for new studies which could lead to further advancement of knowledge and understanding of the unsteady problems of helicopter rotor blades. Author

**N73-14002** Army Air Mobility Research and Development Lab., Moffett Field, Calif.

**DYNAMIC STALL OF AIRFOILS AND HELICOPTER ROTORS**  
W. J. McCroskey. In AGARD Unsteady Aerodyn. of Helicopter Rotors. Oct. 1972. 7 p. refs. (For availability see N73-14000 05-01)

Model helicopter rotor tests to determine the characteristics of retreating blade stall are described. It is shown that the phenomenon may be modeled by the dynamic stall on an oscillating wing. The dynamic overshoot of the static stall conditions to show the shedding of a vortex-like disturbance from the leading edge is discussed. Application of classical static airfoil section data for predicting aerodynamic loads is explained. Author

**N73-14003** Office National d'Etudes et de Recherches Aérospatiales, Paris (France).

**COMPUTATION OF UNSTEADY AERODYNAMIC FORCES ON HELICOPTER ROTOR BLADES**

Jean-Joël Costes. In AGARD Unsteady Aerodyn. of the Helicopter Rotors. Oct. 1972. 16 p. refs. In FRENCH, ENGLISH summary. (For availability see N73-14000 05-01)

Numerical methods for determining the unsteady aerodynamic forces on helicopter rotor blades are presented. The calculation of the velocity potential induced by a lifting surface element when its position, orientation, and lift are known is developed as a function of time. The collocation method makes it possible to express the lift distribution as a function of the velocity component normal to the blades on a network of collocation points distributed on the rotor disc. A comparison between theory and experiment in the case of forward flight is provided. Author

**N73-22948#** Advisory Group for Aerospace Research and Development, Paris (France). Fluid Dynamics Panel.

**HELICOPTER AERODYNAMICS AND DYNAMICS**  
Mar. 1973. 378 p. refs. Lectures presented at Rhode-St-Genes, Belgium, 2-6 Apr. 1973, sponsored in part by von Karman Inst. (AGARD-LS-63). Avail. NTIS HC \$21.00.

The role of aerodynamics and dynamics in helicopter development from the fundamental methods and principles through conceptual design to flight test and proof-of-concept is discussed. The subjects presented include the following: (1) applications of aerodynamics and dynamics to rotary wing aircraft; (2) basic aerodynamics and performance of the helicopter; (3) basic dynamics of rotary wings; (4) aeroelasticity of rotary wing aircraft; (5) helicopter noise analysis; (6) rotary wing model testing in wind tunnels; (6) selection of configuration and prototype design; and (7) flight testing for performance and flying qualities. For individual titles, see N73-22949 through N73-22959.

**N73-22949** Army Air Mobility Research and Development Lab., Moffett Field, Calif.

**THE ROLE OF AERODYNAMICS AND DYNAMICS IN MILITARY AND CIVILIAN APPLICATIONS OF ROTARY WING AIRCRAFT**

Paul F. Yaggy. In AGARD Helicopter Aerodyn. and Dyn. Mar. 1973. 14 p. (For availability see N73-22948 14-01)

The various aerodynamic and dynamic factors which influence the design of helicopters are discussed. The subjects presented are: (1) performance requirements; (2) dynamics, stability, and control; (3) airloads, aeroelasticity, and mechanical instabilities; and (4) proof of technology. Performance charts for typical helicopter configurations are included. Author

**N73-22950** Boeing Co., Philadelphia, Pa. Vertol Div.  
**BASIC AERODYNAMICS AND PERFORMANCE OF THE HELICOPTER**

W. Z. Stepniewski. In AGARD Helicopter Aerodyn. and Dyn. Mar. 1973. 62 p. refs. (For availability see N73-22948 14-01)

The fundamentals of rotary wing aerodynamics and their application to performance considerations of helicopters are discussed. The subjects presented are: (1) momentum theory; (2) blade element theory; (3) fundamentals of vortex theory; (4) applications of theory to design of rotary wing aircraft and performance optimization; and (5) example of helicopter performance prediction based on current industrial practice. Author

**N73-22951** Messerschmitt-Boelkow-Blom G.m.b.H., Ottobrunn (West Germany).

**BASIC DYNAMICS OF ROTORS: CONTROL AND STABILITY OF ROTARY WING AIRCRAFT; AERODYNAMICS AND DYNAMICS OF ADVANCED ROTARY-WING CONFIGURATIONS**

G. Reichert. In AGARD Helicopter Aerodyn. and Dyn. Mar. 1973. 50 p. refs. (For availability see N73-22948 14-01)

Rotary wing configurations such as teetering, articulated, elastomeric-bearing, rotor hub, and hingeless systems are discussed. The basic dynamics of rotary wings are presented to show the elementary forces on a blade element, motion of rotary wing blades, and the influence of inplane stiffness, elastic coupling effects. The mechanics of helicopter flight are analyzed to demonstrate the principles of helicopter control, static and dynamic stability, and maneuver capability. The aerodynamics and dynamics of advanced rotary wing configurations are examined. Author

**N73-22952** Office National d'Etudes et de Recherches Aérospatiales, Paris (France).

**AEROELASTICITY OF ROTARY WING AIRCRAFT**

Roland Dat. In AGARD Helicopter Aerodyn. and Dyn. Mar. 1973. 33 p. refs. (For availability see N73-22948 14-01)

The effects of aeroelasticity on the performance of rotary wing aircraft are discussed. Flutter instability is illustrated by the case of an airfoil and the theoretical tools used to investigate the flutter of a flexible wing are presented. Procedures for predicting the aerodynamic forces on the blades of rotary wings are developed. A formulation of the problem of forced vibration in forward flight is given. Mathematical models are included to support the theoretical considerations. Author

**N73-22953** Loughborough Univ. of Technology (England).  
**HELICOPTER NOISE: ANALYSIS - PREDICTION AND METHODS OF REDUCTION**

Martin V. Lowson. In AGARD Helicopter Aerodyn. and Dyn. Mar. 1973. 37 p. refs. (For availability see N73-22948 14-01)

The fundamentals of helicopter noise radiation phenomena are presented, to include a review of the features of subjective response. Emphasis is placed on the basic mechanisms of rotor noise generation, both for discrete frequency and broad band noise components. The implications for helicopter noise control are discussed. A review of possible propagation effects and the potential costs of helicopter noise reduction are included. Author

**N73-22954** Societe Nationale Industrielle Aérospatiale, Marseille (France). Div. Helicopteres.

**DRAW PROBLEMS ON ROTARY WING AIRCRAFT**

Paul Fabre *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1975 12 p. ref. *In* ENGLISH and FRENCH (For availability see N73-22948 14-01)

The effects of aerodynamic drag on rotary wing performance are analyzed. The influence of stall and compressibility on rotor drag is examined. An example of parasite drag reduction by fairing the rotor head is presented. The nature of helicopter in-flight limitations and methods for improving performance through autogyro configuration and reduction of rotor rotational speed are submitted. Author

**N73-22955** Boeing Co., Philadelphia, Pa. Vertol Div.  
**AERODYNAMIC AND DYNAMIC ROTARY WING MODEL TESTING IN WIND TUNNELS AND OTHER FACILITIES**

Franklin D. Harris *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 62 p. refs (For availability see N73-22948 14-01)

Procedures for testing models of rotary wing aircraft in wind tunnels are discussed. The test objectives involved in rotary wing tunnel tests are described. The characteristics of various testing facilities are analyzed and compared. Methods for obtaining and reducing wind tunnel data are presented. Cost considerations for models and test facilities are analyzed to provide basis for decision on construction and modification. Examples of typical wind tunnel tests conducted with rotary wing models are included. Author

**N73-22956** Boeing Co., Philadelphia, Pa. Vertol Div.  
**FACTORS IN THE DESIGN AND FABRICATION OF POWERED DYNAMICALLY SIMILAR V/STOL WIND TUNNEL MODELS (APPENDIX 1)**

Carl O. Albrecht *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 24 p. refs (For availability see N73-22948 14-01)

The factors involved in the design of a wind tunnel for testing V/STOL aircraft models are discussed. Mach-scaled rotor systems are analyzed to show development and construction. A review of Mach-scaling and Froude-scaling is included to show the relative advantages of each method. Techniques for constructing the models are illustrated. The construction of the test stands and specialized test equipment is explained. Author

**N73-22957** Boeing Co., Philadelphia, Pa. Vertol Div.  
**THE EFFECTS OF REYNOLDS NUMBER ON ROTOR STALL (APPENDIX 2)**

William G. S. Hardy *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 8 p. refs (For availability see N73-22948 14-01)

A theoretical analysis of the effects of Reynolds number on the aerodynamic stalling of rotary wings is presented. A comparison of full scale Reynolds number and model scale Reynolds number for specific airfoil configurations is made. The effects of aeroelasticity on rotary wing performance are analyzed. The relationship of Reynolds number to the aerodynamic coefficients of rotary wings is established. Author

**N73-22958** Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).  
**PARAMETRIC TRENDS AND OPTIMIZATION; PRELIMINARY SELECTION OF CONFIGURATION, PROTOTYPE DESIGN AND MANUFACTURE**

H. Huber *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 55 p. refs (For availability see N73-22948 14-01)

The contribution of aerodynamic and dynamic inputs to the design synthesis of rotary wings is discussed. Aerodynamic rotor design is concentrated on disc loading, tip speed, and solidity selection. Rotor airfoil design is examined under the aspects of compressibility and stall problems. Fundamental flapping and inplane frequencies are shown to be the two basic parameters in dynamic rotor design. Methods of developing various trend curves and their interpretation is supplemented by formal and iterative optimization techniques. Author

**N73-22959** Westland Helicopters, Ltd., Yeovil (England)  
**FLIGHT TESTING FOR PERFORMANCE AND FLYING QUALITIES**

Kieran T. McKenzie *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 15 p. (For availability see N73-22948 14-01)

A review is presented of the required approach to flight testing of rotary wing aircraft in the major areas of performance and flying qualities. Program philosophies, problem areas, techniques of measurement, recording, and analysis are examined and discussed. Some sample measurements and procedures are examined to illustrate approaches. Author

**N74-10806#** Ministry of Defence, London (England).  
**TECHNICAL EVALUATION REPORT ON FLUID DYNAMICS PANEL SPECIALISTS' MEETING ON AERODYNAMIC DRAG**

S. F. J. Butler. Paris AGARD Sep. 1973 14 p. refs. Conf. held at Izmir, Turkey, 10-13 Apr. 1973 (AGARD-AR-58) Avail. NTIS HC \$3.00

The proceedings of a conference on the development of methods for predicting aerodynamic drag are presented. The subjects discussed are: (1) aircraft and wing drag characteristics, (2) helicopter drag, (3) base drag and separation, (4) interaction effects, (5) hypersonic drag, and (7) testing techniques for flight and wind tunnel comparisons. Author

**N74-13709#** Advisory Group for Aerospace Research and Development, Paris (France)  
**DYNAMIC STALL**

P. Cirmi (Avco Corp., Wilmington, Mass.) and P. F. Yaggy, ed. (Army Air Mobility Res. and Develop. Lab., Moffett Field, Calif.) Nov. 1973 41 p. refs. Sponsored by NASA (NASA-CR-136473, AGARD-AG-172) Avail. NTIS HC \$4.25 CSCL 01A

Problems associated with unsteady stall are summarized and past experimental and theoretical studies, relating primarily to dynamic stall of helicopter rotor blades, are reviewed. The problems attendant to analytic treatment of dynamic stall, including identification of relevant flow elements and definition of unsteady separation, are then discussed, and the basis for a theory which accounts for viscous effects and viscous-inviscid interactions analytically is presented. Results of computations are compared with measured loading on an airfoil undergoing sinusoidal pitching motion. The amounts of lift overshoot and their variation with frequency are in good agreement. Analyses of wake-induced stall and stall flutter of a helicopter rotor blade are then presented. The results indicate that the large stall-related torsional oscillations which commonly limit helicopter forward speed are the response to rapid changes in aerodynamic moment which accompany stall and unstall, rather than the consequence of an aeroelastic instability. Author

**N74-13710#** Advisory Group for Aerospace Research and Development, Paris (France)  
**MAGNUS CHARACTERISTICS OF ARBITRARY ROTATING BODIES**

I. D. Jacobson (Va. Univ.) and P. F. Yaggy, ed. (Army Air Mobility Res. and Develop. Lab., Moffett Field, Calif.) Nov. 1973 62 p. refs (AGARD-AG-171) Avail. NTIS HC \$5.25

Theoretical and experimental investigations of the Magnus effect on arbitrary bodies of revolution are reviewed. The main emphasis is on spinning projectiles at angle of attack, both with and without fins. Flow visualization measurements are used to assess the accuracy of the existing theories. Laminar, turbulent and mixed boundary layers are considered. Author

**N74-14709#** Advisory Group for Aerospace Research and Development, Paris (France)  
**AERODYNAMIC DRAG**

Oct. 1973 469 p. refs. Partly in ENGLISH and partly in FRENCH. Proc. of the Fluid Dyn. Panel Specialists Meeting, Izmir, Turkey, 10-13 Apr. 1973 (AGARD-CP-124) Avail. NTIS HC \$25.50

The proceedings of a conference on aerodynamic drag are presented. Current research and future prospects in the field of



aerodynamic drag are considered. Main emphasis was placed on subjects of practical value to the aerospace industry in relation to the need for accurate prediction, measurement, and alleviation of drag. Some of the subjects considered are: (1) aircraft drag, (2) wing drag, (3) base drag and separation, (4) interaction effects, (5) hypersonic drag, and (6) testing techniques and correlation of flight test and wind tunnel test data. For individual titles, see N74-14710 through N74-14738.

N74-14710 Ministry of Defence, London (England)

#### TECHNICAL EVALUATION REPORT

S F J Butler. In AGARD Aerodyn Drag Oct 1973 11 p  
(For availability see N74-14709 06-01)

A primary objective of research on aerodynamic drag is the development and proving of prediction methods in a form suitable for direct use by aircraft development teams and by those who have to assess the relative merits of alternative designs. Aircraft drag estimation methods are needed at various levels of sophistication and reliability. Basic statistical analyses can form the basis of an acceptable forecasting procedure at the feasibility stage, although such an approach is essentially conservative and can lead to the perpetuation of low design standards, as well as being of little use when novel aircraft design concepts are under consideration. Of some significance is the ability to predict reliably the drag of a datum streamlined aircraft with fully-turbulent flow, against which achieved drag levels can be compared in a figure-of-merit approach. During the design development and refinement stage, the research aims include the achievement of drag design objectives and the limitation of drag growth. In this phase, drag predictions in practice must be prepared by a process of synthesis (rather than simple summation), within a format which can readily accommodate the changing sources of data.

Author

N74-14711 Lockheed-Georgia Co., Marietta

#### A SURVEY OF DRAG PREDICTION TECHNIQUES APPLICABLE TO SUBSONIC AND TRANSONIC AIRCRAFT DESIGN

J H Patterson, D G MacWilkinson, and W T Blackerby. In AGARD Aerodyn Drag Oct 1973 38 p refs (For availability see N74-14709 06-01)

The following aspects of aircraft drag prediction in the subsonic to transonic range are discussed: (1) preliminary estimation procedures, (2) estimation using wind tunnel test data, and (3) wind tunnel data and flight test data correlation. Inaccuracies in the approach to the use of flat plate skin friction, with appropriate shape factors, to predict profile drag are identified. Attempts to use low Reynolds number wind tunnel drag levels to predict full scale drag are shown to be reasonably successful. The prediction of C-5A aircraft drag characteristics from wind tunnel tests is discussed.

Author

N74-14712 Naval Weapons Lab., Dahlgren, Va

#### AERODYNAMIC DRAG AND LIFT OF GENERAL BODY SHAPES AT SUBSONIC, TRANSONIC AND SUPERSONIC MACH NUMBERS

Frankie G Moore. In AGARD Aerodyn Drag Oct 1973 11 p refs (For availability see N74-14709 06-01)

Several theoretical and empirical methods are combined into a single computer program to predict drag, lift, and center of pressure on bodies of revolution at subsonic, transonic, and supersonic Mach numbers and for angles of attack to twenty degrees. The body geometries can be quite general in that pointed, spherically blunt, or truncated noses are allowed as well as discontinuities along the nose. Particular emphasis is placed on methods which yield accuracies of ninety percent or better for most configurations but yet are computationally fast. To handle the blunt nosed configurations, a new procedure has been employed that of combining modified Newtonian theory with perturbation theory. Theoretical and experimental results are presented for several projectiles and the comparisons meet the general accuracy requirements above. The combined perturbation - Newtonian theory gave pressures which compared better with experiment than any existing approximate technique in the lower supersonic speed regime.

Author

N74-14713 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Aerodynamik

#### ON SOME BASIC AND NEW ASPECTS ABOUT THE DRAG PROBLEM OF WINGS AND BODIES IN SUPERSONIC FLOWS

Arabindo Das. In AGARD Aerodyn Drag Oct 1973 26 p refs (For availability see N74-14709 06-01)

With the objective to determine optimum shapes of slender wings and bodies for minimum total drag in supersonic flows a comprehensive theoretical and experimental analysis of the problem has been carried out. The theoretical formulas for the various drag components which are necessary for a variational problem of drag minimization have been reviewed, summarized, partly modified or extended, and finally compared with experimental values. Based on the linearized mass flux concept already known in the literature a modified boundary condition leads to a certain improvement in the results of the linear theory. A simplified treatment of the modified linear theory is presented. A unified approach to the problem of minimization of wave drag due to volume and wave drag due to lift yields very simple analytical results. The optimum body shapes show a certain dependence on Mach number. For minimization of vortex drag the necessary wing twist yields a remarkable improvement, which could also be verified by experiment. While the known friction drag formulas from the literature have been checked with experimental values, the problem of base drag of axial symmetrical bodies has not been completely solved as yet. Theoretical work on this topic is being continued.

Author

#### N74-14714 Royal Aircraft Establishment, Bedford (England) MEASUREMENTS OF THE DRAG OF SOME CHARACTERISTIC AIRCRAFT EXCRESCENCES IMMERSED IN TURBULENT BOUNDARY LAYERS

L Gaudet and K G Winter. In AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

Measurements are described of the drag of various forms of excrescence mounted on balances installed in the walls of the working section of the RAE 8 ft x 8 ft wind tunnel. The tests cover a range of Mach numbers between 0.2 and 2.8 (but not transonic) and a range of Reynolds number. The excrescences tested include two-dimensional steps and ridges, circular cylinders and wings mounted normal to the surface, and holes and fairings. It is shown, for excrescences which are of height small compared with the boundary-layer thickness, that the scale effects on drag are well correlated in terms of the wall variables of the turbulent boundary layer, but that there is a dependence of drag on Mach number. For steps and ridges the effect of chamfering or rounding the upper corners was found to be beneficial at subsonic speeds but far less so at supersonic speeds. For circular holes the drag depends strongly upon the depth to diameter ratio. The fairings tested were either half-bodies of revolution with pointed or rounded ends or of square or rectangular section with pointed ends. The effects of different amounts of immersion of the bodies into the boundary layer was found in some cases by testing geometrically similar bodies of different sizes.

Author

N74-14715 Messerschmitt-Boelkow-Blohm G m b H, Ottobrunn (West Germany)

#### PROBLEMS OF ESTIMATING THE DRAG OF A HELICOPTER

S N Wagner. In AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

The components which contribute to the drag of a helicopter are identified as (1) the drag of the main and tail rotors, (2) fuselage drag, (3) pylon drag, (4) landing gear drag, (5) fairing drag, and (6) drag caused by interference between the helicopter components. The difficulties and advantages of methods for defining the drag of a helicopter are analyzed. Procedures for testing small scale models of helicopters are discussed. The correlation of model data with flight test data is examined.

Author

N74-14716 Royal Aircraft Establishment, Farnborough (England)

#### AIRCRAFT DRAG PREDICTION FOR PROJECT APPRAISAL

**AND PERFORMANCE ESTIMATION**

S F J. Butler *In* AGARD Aerodyn Drag Oct 1973 50 p  
(For availability see N74-14709 06-01)

The principal stages in aircraft feasibility study and design development are considered, leading to the specification of desirable characteristics of aircraft drag prediction models. The contributions to drag modelling to be expected from research are reviewed, together with the impact of computerized design selection and mission analysis methods. An assessment of the relative importance of different components and sources of drag introduces surveys, which examine the present state of the art of prediction for specific classes of aircraft and for particular aspects of drag. The main problems involved in executing and analysing model and aircraft tests are also discussed in the drag context. The collection, analysis and dissemination of data suitable for direct use in practical design methods are discussed. Author

N74-14717 Engineering Sciences Data Unit, London (England)

**APPENDIX: A DATA ITEM SERVICE FOR AIRCRAFT DRAG ESTIMATION**

*In* AGARD Aerodyn Drag Oct 1973 9 p refs (For availability see N74-14709 06-01)

Avail NTIS

The terms of reference for an engineering unit concerned with determining aerodynamic drag are discussed. The functions of the organization are defined: (1) to collect and disseminate information on drag prediction for sweptwing aircraft, (2) to arrange for the correlation and analysis of relevant data, (3) to formulate a comprehensive framework for the analysis and synthesis of aircraft drag, and (4) to encourage the introduction and adoption of improved drag prediction methods. Author

N74-14718 Douglas Aircraft Co., Inc., Long Beach, Calif  
**REMARKS ON METHODS FOR PREDICTING VISCOUS DRAG**

A M O Smith and Tuncer Cebeci *In* AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

While predictions of low speed profile drag are accurate for mono-element airfoils at low angle of attack, the methods are not very accurate at higher angles of attack, or for multi-element airfoils or for latter bodies of revolution. Two courses that might lead to possible improvement in accuracy have been investigated. One was an attempt to perform direct shear and pressure stress calculations on an airfoil or body. The other was an attempt to improve the Squire-Young momentum defect method by actually solving the wake for a short distance. The first method was not successful but the second method shows promise. Hence, it is tentatively concluded that refinement of the momentum defect method is the most promising path towards improved accuracy. Author

N74-14719 National Aeronautical Establishment, Ottawa (Ontario)

**DRAG OF SUPERCRITICAL AIRFOILS IN TRANSONIC FLOW**

J J Kacprzyński *In* AGARD Aerodyn Drag Oct 1973 20 p refs (For availability see N74-14709 06-01)

Analytical methods of evaluation of drag coefficients of contemporary supercritical airfoils are discussed. Some results of experimental values of drag coefficient for supercritical airfoils are compared against results of theoretical evaluations. Some results of drag coefficients of conventional airfoils are included for comparison. Difficulties of accurate experimental recording of drag coefficients are indicated. Author

N74-14720 General Dynamics/Convair, San Diego, Calif  
Aerospace Div

**TRANSONIC DRAG DUE TO LIFT OF PLANAR JET-FLAPPED AIRFOILS**

H Yoshihara, R Magnus and D Zonars (AFFDL) *In* AGARD Aerodyn Drag Oct 1973 8 p refs (For availability see N74-14709 06-01)

In contrast to the low speed case test results indicate that lift augmentation by the jet flap in the transonic regime is

accompanied, not by a large thrust recovery, but by a significant increase in drag. However, to achieve moderate to high lifts the use of jet flaps rather than incidence has led to a significant reduction in the drag due to lift. To calculate the transonic jet flap flow a modified Spence jet flap condition is postulated and incorporated into the (unsteady) finite difference procedure. An example is then calculated and compared with experimental results. Author

N74-14721 National Aerospace Lab., Amsterdam (Netherlands)

**COMPARISON OF VARIOUS METHODS FOR CALCULATING PROFILE DRAG FROM PRESSURE MEASUREMENTS IN THE NEAR WAKE AT SUBCRITICAL SPEEDS**

J Zwaaneveld *In* AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

Methods for calculating the profile drag from total and static pressure measurements in aircraft wake have been compared. An analytical model of a compressible two-dimensional wake is used to obtain numerical results. Both the oldest method of Betz and the widely used method of Jones allow the static pressure variation across the wake to be taken into account. These methods are therefore suitable to treat the flow in the very near wake. The third method developed by Squire and Young is in principle only valid when the static pressure variation across the wake is negligible. To extend this method to the more general case, two modifications are considered, the first as proposed by Squire and Young, the second as presented by the author. The latter modification makes use of the momentum integral equation with modified parameters. The numerical results show this new approach to be in far better agreement with the method of Jones than the first mentioned modified version. Author

N74-14722 Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**DRAG AND SEPARATION**

Maurice Sirrix *In* AGARD Aerodyn Drag Oct 1973 23 p refs *In* FRENCH, ENGLISH summary (For availability see N74-14709 06-01)

The unsteady character of some separated flows and their resulting effects are discussed. The different types of turbulent separated flows of a limited extent and quasi-steady character are defined. The expected effects of these separated flows on the aerodynamic drag were studied. Theoretical methods of prediction are explained. Examples in which separated flows appear are analyzed. Author

N74-14723 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)

**NEW INVESTIGATIONS FOR REDUCING THE BASE DRAG OF WINGS WITH A BLUNT TRAILING EDGE**

Mauri Tanner *In* AGARD Aerodyn Drag Oct 1973 9 p refs (For availability see N74-14709 06-01)

Investigations were conducted to determine methods for reducing the base drag of wings with blunt trailing edges. Measurements were performed on a rectangular wing in a low speed wind tunnel. The wing was fitted with broken trailing edges, splitter plates and splitter wedges. The tests showed that the base drag could be substantially reduced by fitting a splitter wedge on the trailing edge. For the most advantageous splitter wedge, the base drag was nearly zero. In this case the maximum lift to drag ratio for the wing with a blunt trailing edge was as great as that for the corresponding wing with a conventional sharp trailing edge. Author

N74-14724 Illinois Univ., Urbana Dept of Mechanical and Industrial Engineering

**A STUDY OF FLOW SEPARATION IN THE BASE REGION AND ITS EFFECTS DURING POWERED FLIGHT**

A L Addy, H H Korst, R A White and B J Walker (Army Missile Command, Redstone Arsenal, Ala.) *In* AGARD Aerodyn Drag Oct 1973 15 p refs (For availability see N74-14709 06-01)

The effect of the separated flow region on the performance of aircraft and missiles during powered flight is discussed. The interaction between the propulsive jet and the free stream flows is emphasized. The Chapman-Korst component flow model allows the qualitative and quantitative discussion of the effects of the afterbody-base problem of all pertinent design and performance parameters. The usefulness of the component approach has been enhanced by semi-empirical modifications, improvements of individual components, and the development of computer programs. It is shown that the onset and location of plume-induced separation of the external flow can be predicted given a suitable boundary layer separation criterion. Author

**N74-14726 LTV Aerospace Corp., Dallas, Tex**  
**PREDICTION OF BUFFET ON-SET FOR AIRCRAFT. RECENT**  
**PROGRESS IN WIND TUNNEL AND FLIGHT TEST DATA**  
**CORRELATION**

R C McWhorter. In AGARD Aerodyn Drag Oct. 1973 8 p refs (For availability see N74-14709 06-01)

Methods for predicting and determining the onset of buffet during aircraft flight are analyzed. The buffet characteristics of F-4 and F-8 aircraft are reported. Diagnostic data on wind tunnel flow is examined to determine the property or properties which are necessary to obtain repeatable, sensible buffet onset predictions from model testing. The characteristics of wind tunnels which affect the results of buffet investigations are examined. Author

**N74-14728 Air Force Flight Dynamics Lab., Wright-Patterson**  
**AFB, Ohio**  
**ASSESSMENT OF THE INFLUENCE OF INLET AND**  
**AFTBODY/NOZZLE PERFORMANCE ON TOTAL AIRCRAFT**  
**DRAW**

Philip P. Antonatos, Lewis E. Surber, James A. Laughrey, and Donald J. Stava. In AGARD Aerodyn Drag Oct. 1973 28 p refs (For availability see N74-14709 06-01)

The influence of propulsion system installation on aircraft drag is discussed. Using information from several investigations, different aspects of airframe-propulsion integration are explored, each of which affects the assessment of aircraft drag. A great deal of apparently conflicting data has been generated on airframe-propulsion integration simply because the investigators concerned with different aspects of a system development have not properly integrated their own efforts to assure that theoretical analysis methods are consistent with wind tunnel test methods, that the test models are consistent with each other, and that adequate corrections for the effect of model mounting systems can be made. Even rather small inconsistencies in just a few of these considerations may result in errors of sufficient magnitude to affect aircraft design decisions adversely. A major part of the difficulty of making an accurate assessment of inlet/aftbody/nozzle effect on aircraft drag is the prediction of flight performance from wind tunnel test data. Early system development should be studied carefully to assure that the program of airframe-propulsion integration and the demands on propulsion related drag assessment are consistent with drag estimate accuracy for the airframe. Author

**N74-14727 Boeing Commercial Airplane Co., Renton, Wash**  
**THE PROBLEM OF INSTALLING A MODERN HIGH BYPASS**  
**ENGINE ON A TWIN JET TRANSPORT AIRCRAFT** c02  
 Walter C. Swan and Armand Sigalla. In AGARD Aerodyn Drag Oct. 1973 12 p (For availability see N74-14709 06-01)

An examination of the engine placement on a modern jet transport presents new drag and stability problems. Large high bypass ratio engines create large annular and wetted area drag and blockage surfaces which can cause difficult configuration problems as well as large interference drag and stability effects. The option is open to conventional underwing and aftbody mounted installations as well as renewed opportunity for over-the-wing installations. In this paper the drag and stability consequences for each class of configuration is examined for a typical intermediate range transport. The results are equally valid for short haul and certain STOL missions. In some instances it is shown, proper pod shape and positioning may result in favorable

drag increments, especially on modern swept wings with supercritical airfoil sections. Side effects such as pod influences on wing flutter, deep stall, and general sizing of the empennage are discussed. Author

**N74-14728 National Aeronautical Establishment, Ottawa**  
**(Ontario)**  
**THE DRAG RESULTING FROM THREE-DIMENSIONAL**  
**SEPARATIONS CAUSED BY BOUNDARY-LAYER DIVERT-**  
**ERS AND NACELLES IN SUBSONIC AND SUPERSONIC**  
**FLOW**

David J. Peake and William J. Rainbird (Carleton Univ.) In AGARD Aerodyn Drag Oct. 1973 22 p refs (For availability see N74-14709 06-01)

Three-dimensional viscous flow separations and their effect on configuration drag are examined in high Reynolds number tests conducted in the NAE 5 ft x 5-ft blowdown wind tunnel in both subsonic and supersonic flow. In particular, emphasis is placed on the geometry of the system to divert the oncoming boundary layer about propulsion nacelles. To avoid significant three-dimensional separations, avoid imposing large adverse streamwise pressure gradients upon an oncoming boundary layer, such as those produced near stagnation point regions of bluff diverters, or adjacent to intakes operating below design mass flow. The avoidance of these strong streamwise pressure gradients is seen to be readily achieved by increasing the diverter slenderness ratio and by keeping intakes operating at design conditions by means of auxiliary by-pass arrangements. Author

**N74-14729 Royal Aircraft Establishment, Bedford (England)**  
**THE DRAG OF EXTERNALLY CARRIED STORES: ITS**  
**PREDICTION AND ALLEVIATION**

P. G. Pugh and P. G. Hutton. In AGARD Aerodyn Drag Oct. 1973 11 p refs (For availability see N74-14709 06-01)

The installed drag of stores makes a major contribution to the total drag of combat aircraft. It can be several times the sum of the free-air drags of the individual stores and its prediction and reduction are essential to the design of high-performance aircraft. Interference effects involved range from simple buoyancy to complex interactions involving viscous and wave drag phenomena. For the simpler cases there are good prospects that the installed drag can be accurately predicted either by current methods or by relatively straightforward extensions of these. However, empirical methods will continue to be needed for the prediction of the drag of complicated cases eg multiple store arrays at transonic speeds. Some examples are given to show the opportunities for reducing the installed drag either by redesigns to take advantage of improved mechanical systems or through the development of radically new installations. Author

**N74-14730 Deutsche Forschungs- und Versuchsanstalt fuer**  
**Luft- und Raumfahrt, Goettingen (West Germany)**  
**DRAG IN HYPERSONIC RAREFIED FLOW**

Walter Wuest. In AGARD Aerodyn Drag Oct. 1973 12 p refs (For availability see N74-14709 06-01)

The drag force in hypersonic flow may be divided into cold pressure drag (incident molecules), temperature depending pressure drag (diffusively reflected molecules) and friction drag. The pressure drag dominates on blunt bodies which show a slighter drag variation with rarefaction whereas on slender bodies friction drag dominates and the total drag is strongly influenced by rarefaction. Relaxation and radiation do not appreciably alter the pressure drag but influence the flow field, stand-off distance of shock wave, and heat transfer. Author

**N74-14731 Centre National de la Recherche Scientifique,**  
**Meudon (France) Lab d'Aerothermique**  
**DRAG OF LIFTING BODIES FOR PILOTS AT HIGH**  
**ALTITUDE [TRAINEE DE CORPS PORTANTS PILOTES A**  
**HAUTE ALTITUDE]**

J. Allegre, C. Metrand, and M. F. Scibilia. In AGARD Aerodyn Drag Oct. 1973 10 p refs. In FRENCH. ENGLISH summary (For availability see N74-14709 06-01)

Lifting bodies with 60 deg swept delta wings fitted out with control devices, located near the trailing edge of the wings are analyzed. The present experimental study of the aerodynamic

behaviour of the wing is realized in a rarefied flow simulating a flight altitude of about 70 km. Experiments are performed in an open jet and continuously operating wind tunnel. The air flow is characterized by a Mach number of 8.1 and a free stream Reynolds number of 2200 per cm. Results show how much aerodynamic devices associated with the delta wing, like spoilers, remain efficient and can be used in order to control the trajectory at high altitude. Drag coefficient data are given in the range of incidences between minus 20 deg and 20 deg. A comparison between efficiencies of trailing edge solid spoilers and trailing edge fluid spoilers allows to point out some advantages of the fluid spoilers. In particular, this jet control mechanism can create a sufficient side thrust without entailing a large increase of the drag. Author

**N74-14732** Aentala, Turin (Italy)

**A REVIEW OF SUPERSONIC SPHERE DRAG FROM THE CONTINUUM TO THE FREE MOLECULAR FLOW REGIME**  
E. Vallerani. In AGARD Aerodyn Drag Oct 1973 15 p refs (For availability see N74-14709 06-01)

The evaluation of the sphere drag coefficient has been the object of extensive theoretical investigations for a long time. A large amount of experimental data has been collected to substantiate those studies and to provide the needed information for the flow regimes for which the theoretical approaches are still missing. The scope of the present review is to attempt the establishment of a more complete panorama of the supersonic sphere drag predictions over the entire range of flow regimes ranging from the continuum flow to the free molecular flow, in order to provide in a consistent form the design engineer of the information required for the aerodynamic design of space vehicles. The theoretical methods developed to cover the various flow regimes such as: (1) continuum low density, (2) free molecular, (3) near free molecular, and (4) intermediate have been reviewed and discussed in the light of the comparison with the pertinent experimental data available. New semiempirical formulas for the correlation of the experimental data are derived for the low density continuum flow and for the near free molecule flow regimes. For the intermediate flow regimes, ranging between the continuum flow and the free molecular flow, the results of a semiempirical method recently developed by the author are presented and discussed. Author

**N74-14733** Ruhr Univ., Bochum (West Germany)

**THE INFLUENCE OF WAKE DRAG ON HYPERSONIC ENTROPY WAKE OBSERVATIONS**

Wolfgang Merzkirch and Alois Stulp (Ernst-Mach-Inst.) In AGARD Aerodyn Drag Oct 1973 6 p refs (For availability see N74-14709 06-01)

The conditions existing in the wake of a blunt hypersonic body are discussed. The two different flow regimes are defined as: (1) the viscous wake which originates from the separated boundary layer and (2) the inviscid or entropy wake formed by the streamlines which have traversed the curved part of the bow shock. The flow visualization of the entropy wake by schlieren photography is described. The observed schlieren pattern is analyzed with the aid of optical schlieren theory and can be related to the flight Mach number and the drag coefficient of the body. Author

**N74-14734** Naval Air Systems Command, Washington, D.C.  
**DEVELOPMENT OF TECHNIQUES TO MEASURE IN-FLIGHT DRAG OF A US NAVY FIGHTER AIRPLANE AND CORRELATION OF FLIGHT MEASURED DRAG WITH WIND TUNNEL DATA**

E. C. Rooney. In AGARD Aerodyn Drag Oct 1973 18 p (For availability see N74-14709 06-01)

Wind tunnel and flight drag measurement techniques and correlation of wind tunnel and flight drag data for a U.S. Navy fighter airplane are discussed. Wind tunnel drag data were obtained with aerodynamic, induction system and powered nozzle/afterbody models. A common reference afterbody configuration between aerodynamic and propulsion models was utilized to assure compatibility of thrust and drag measurements. Flight drag data were obtained from steady-state, quasi-steady-state and dynamic

(wind-up/down turn) maneuvers utilizing sensitive three-axis accelerometers to determine excess thrust and the internal pressure method for measuring engine thrust. Compressor airflow, afterburner pressure drop and nozzle coefficients used for computing engine net thrust were obtained from isolated engine tests at simulated flight conditions throughout the flight envelope. Wind tunnel data were used to account for propulsion system drag caused by subcritical inlet spillage and nozzle interference drag. Author

**N74-14735** National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif

**REVIEW OF DRAG MEASUREMENTS FROM FLIGHT TESTS OF MANNED AIRCRAFT WITH COMPARISONS TO WIND-TUNNEL PREDICTIONS**

Jon S. Pyle and Edwin J. Saltzman. In AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

In-flight studies of the overall and local components of drag of many types of aircraft were conducted. The primary goal of these studies was to evaluate wind-tunnel and semiempirical prediction methods. Some evaluations are presented in this paper which may be summarized by the following observations: Wind-tunnel predictions of overall vehicle drag can be accurately extrapolated to flight Reynolds numbers, provided that the base drag is removed and the boattail areas on the vehicle are small. The addition of ablated roughness to lifting body configurations causes larger losses in performance and stability than would be expected from the added friction drag due to the roughness. Successful measurements of skin friction have been made in flight to Mach numbers above 4. A reliable inflatable deceleration device was demonstrated in flight which effectively stabilizes and decelerates a lifting aircraft at supersonic speeds. Author

**N74-14736** Royal Armament Research and Development Establishment, Fort Halstead (England)

**AN ASSESSMENT OF THE ACCURACY OF TRANSONIC DRAG MEASUREMENT IN A LARGE MODERN WIND TUNNEL**

K. Fancett and T. Smith. In AGARD Aerodyn Drag Oct 1973 11 p refs (For availability see N74-14709 06-01)

The aeroballistic coefficients of bodies of revolution are needed for the mathematical modelling of their trajectories. The most significant coefficient required is zero yaw drag and the accuracy required is about 0.5% for a perfect trajectory model, compared with about 5% for lift and overturning moment. Lift, drag and overturning moment were measured over a range of yaw angles on two sting lengths in a 2.4 m x 2.7 m transonic wind tunnel. There was a marked difference in the measured drag values for these stings and a further investigation was made with five sting lengths. From these tests an empirical correction for the support system was derived which agreed well with a subsonic theoretical estimate. At speeds above Mach 1.0 the irregularity of the tunnel axial pressure distribution dominated the effects due to the support system and a combined correction was derived. It was found that the difference in measured values after correction was very much less than before, over the whole Mach number range, thus supporting the correction procedure applied. A statistical analysis of the residual coefficient errors has been summarized for the subsonic and transonic speed regions. The transonic percentage errors were generally less than the subsonic values, due to the larger coefficient values measured. Author

**N74-14737** City Univ., London (England) Dept. of Aeronautics

**STING INTERFERENCE EFFECTS ON AFTERBODIES AT TRANSONIC SPEEDS**

D. M. Sykes. In AGARD Aerodyn Drag Oct 1973 9 p refs (For availability see N74-14709 06-01)

The pressure distribution over the surface of three axisymmetric afterbodies at zero incidence has been measured and sting interference effects determined through the Mach number range from 0.70 to 1.15 in an octagonal, slotted wall wind tunnel. The afterbodies tested were a simple cylinder and conical boat-tails 1/2 calibre long with 7 1/2 deg angle and 1 calibre

long with 9 deg angle, each carrying a representative driving bend. Sting diameter effects were determined using 4 calibre long cylindrical stings of diameter 1/8, 1/4, 3/8 and 1/2 calibre, and sting flare interference effects were determined for a 10 deg semi-angle cone on a 1/4 calibre sting. The tests showed that the ratio of sting to base diameter was the main parameter for interference effects, but data for diameter effect from afterbodies with other geometries was not fully correlated using this parameter. Successful correlation with other data has been achieved for the proximity of conical flares of different angles for subsonic flow conditions.

Author

**N74-14738** Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France)

**MEASUREMENT OF DRAG IN A SHOCK TUNNEL (MESURES DE TRAINEE EN TUNNEL DE TIR)**

Daniel Bahurel and Alain Desgardin. In AGARD Aerodyn Drag Oct 1973 14 p refs. In FRENCH (For availability see N74-14709 06-01)

After summarizing the principles of drag measurement in a shock tunnel, the different methods actually used are given.  $C_x$  constant,  $C_x$  as a function of incidence, and  $C_x$  as a function of Mach number. The accuracy of the methods is included. A series of results, obtained in the L R B A shock tunnel, on spherico-conic and cylindro-conic projectile slip over a broad range of Mach numbers and at 15 degree incidence angle are presented.

Transl by E.H.W.

**N74-18652\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va

**COMMENTS ON NASA LANGLEY RESEARCH ON TRANSONIC UNSTEADY AERODYNAMICS**

Samuel R Bland. Paris AGARD Dec 1973 14 p refs. Presented at 36th AGARD Structures and Mater. Panel Meeting, Milan, 4 Apr 1973. (NASA-TM-X-69997, AGARD-R-611) Avail NTIS HC \$4.00 CSCL 01A

Accurate unsteady transonic aerodynamics for use in flutter calculation are considered. Five different methods of analysis are described, each of which attempts to treat some of the non-linear aspects of the transonic flow. Where possible, calculated results are given.

Author

**N74-18653/** Advisory Group for Aerospace Research and Development, Paris (France)

**ON THE PREDICTION OF AERODYNAMIC LOADS ON OSCILLATING WINGS IN TRANSONIC FLOW**

H. Tijdeman (Natl. Aerospace Lab., Amsterdam) and R. J. Zwaan (Natl. Aerospace Lab., Amsterdam). Jan 1974 30 p refs. Presented at 36th AGARD Structures and Mater. Panel Meeting, Milan, 4 Apr 1973.

(AGARD-R-612) Avail NTIS HC \$4.50

Possibilities to develop calculation methods for oscillating wings in transonic flow are discussed. Special attention is given to the question of linearization. Pressure measurements on an aerofoil with flap in transonic flow are analyzed. Correlations are made between steady, quasi-steady and unsteady results. Shock motion and shock strength are investigated. Also linearity is discussed. A calculation method for high subsonic flow is suggested.

Author

**N74-18654/** Advisory Group for Aerospace Research and Development, Paris (France)

**INTERFERING LIFTING SURFACES IN UNSTEADY SUBSONIC FLOW: COMPARISON BETWEEN THEORY AND EXPERIMENT**

Juergen Becker (Messerschmitt-Boelkow-Blohm, Munich). Jan 1974 20 p refs. Presented at 37th AGARD Structures and Mater. Panel Meeting, the Hague, 7-12 Apr 1973.

(AGARD-R-614) Avail NTIS HC \$4.00

The results of experimental and analytical research work on the flutter with complete aircraft models showed considerable shifting of critical flutter speeds due to interfering aerodynamic forces, particularly where models of variable geometry were concerned. This was the reason for the development of

aerodynamic interference procedures for two or more oscillating surfaces. In order to calculate interfering aerodynamic forces, theoretical procedures were developed which may be divided into lifting surface theories and double lattice methods. Measurements of unsteady pressure distributions on a variable wing-tail configuration, were compared with the results of the lifting surface theory.

Author

## 02 AIRCRAFT

Includes fixed-wing airplanes, helicopters, gliders, balloons, ornithopters, etc.; and specific types of complete aircraft (e.g., ground effect machines, STOL and VTOL), flight tests, operating problems (e.g., sonic boom), safety and safety devices, economics, and stability and control. For basic research see 01 Aerodynamics. For related information see also 31 Space Vehicles; and 32 Structural Mechanics.

**N71-20051#** Advisory Group for Aerospace Research and Development, Paris (France)

#### ASSESSMENT OF LIFT AUGMENTATION DEVICES

Feb 1971 284 p refs Presented at the Lecture Series, Rhode-Saint-Genese, Belgium, 20-24 Apr 1970. Sponsored by AGARD and von Karman Inst (AGARD-LS-43-71) Avail NTIS

#### CONTENTS

- 1 AERODYNAMICS OF MECHANICAL HIGH LIFT DEVICES  
D. M. McRae (Hawker Siddeley Aviation, Ltd., Hatfield, England) 23 p refs (See N71-20052 09-02)
- 2 AERODYNAMICS OF PNEUMATIC HIGH LIFT DEVICES  
J. von der Decken (Tech Hochschule Carolo Wilhelmina) 36 p refs (See N71-20053 09-02)
- 3 AERODYNAMICS OF VARIABLE SWEEP  
Ph. Poisson-Quinton (Office Natl d'Etudes et de Recherches Aérospatiales, Paris, France) 19 p refs (See N71-20054 09-02)
- 4 FUNDAMENTAL ASPECTS OF FLOW SEPARATION UNDER HIGH LIFT CONDITIONS  
H. P. Horton (Von Karman Inst for Fluid Dynamics) 19 p refs (See N71-20055 09-01)
- 5 SOME NOTES ON TWO DIMENSIONAL HIGH LIFT TESTS IN WIND TUNNELS  
B. van den Berg (Natl Lucht-en Ruimtevaartlaboratorium) 18 p refs (See N71-20056 09-01)
- 6 MODEL TESTING REQUIREMENTS AND TECHNIQUES FOR HIGH LIFT SCHEMES  
THREE DIMENSIONAL ASPECTS  
C. Russell (British Aircraft Corp, Warton, England) 22 p refs (See N71-20057 09-01)
- 7 ANALYSIS OF TRANSPORT APPLICATIONS FOR HIGH LIFT SCHEMES  
L. B. Graizer (Boeing Co., Seattle, Wash) 23 p refs (See N71-20058 09-02)
- 8 ANALYSIS OF COMBAT AIRCRAFT APPLICATIONS FOR LIFT AUGMENTATION DEVICES  
R. Taisseire (Breguet Aviation) 21 p (See N71-20059 09-02)
- 9 FLIGHT TESTING MILITARY TRANSPORT AIRCRAFT FOR CLEARANCE IN THE STOL ROLE  
K. P. Eyre (Aeroplane and Armament Experimental Establishment) 24 p ref (See N71-20060 09-02)
- 10 LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE  
PART 1 INTERFACE PROBLEMS BETWEEN ENGINE AND AIRFRAME  
J. A. Hooper (Rolls-Royce, Ltd., Bristol, England) 18 p (See N71-20061 09-02)
- 11 LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE  
PART 2 THERMODYNAMIC PROBLEMS AND SOME POSSIBLE SOLUTIONS  
E. A. White and H. C. Hillier (Rolls-Royce, Ltd., Bristol, England) 13 p (See N71-20062 09-02)
- 12 OPTIMISING THE PROPULSIVE/LIFT SYSTEM FOR TURBOFAN STOL AIRCRAFT CONSIDERING COST EFFECTIVENESS  
H. T. Bowling (Lockheed-Georgia Co., Marietta) 14 p (See N71-20063 09-28)
- 13 A NEW TECHNIQUE FOR AEROFOIL LEADING EDGE STUDIES  
J. Monnerie (Office Natl d'Etudes et de Recherches Aérospatiales, Paris, France) 5 p ref (See N71-20064 09-02)
- 14 SOME COMMENTS ON CHARACTERISTICS OF HIGH LIFT WINGS  
D. N. Foster (Royal Aircraft Establishment, Farnborough, England) 5 p refs (See N71-20065 09-02)
- 15 THE HUNTING H 128 JET FLAP RESEARCH AIRCRAFT

K. D. Harris (Hawker Siddeley Aviation, Ltd., Hatfield, England) 7 p refs (See N71-20066 09-02)

16 AERODYNAMIC RESEARCH ON HIGH LIFT SYSTEMS  
F. Mavropis (Canadair, Ltd.) 13 p refs (See N71-20067 09-02)

**N71-20062#** Hawker Siddeley Aviation, Ltd., Hatfield (England) Aerodynamic Dept.

#### AERODYNAMICS OF MECHANICAL HIGH LIFT DEVICES

D. M. McRae In AGARD Assessment of Lift Augmentation Devices Feb 1971 23 p refs (See N71-20051 09-02)  
Avail NTIS

The purpose is to describe in general terms the stalling of conventional airfoils and the effects of mechanical high lift devices thereon. The factors affecting maximum lift coefficient are discussed in the context of estimation methods. Drag is also discussed. Author

**N71-20063#** Technische Hochschule Carolo Wilhelmina, Brunswick (West Germany) Inst für Stromungsmechanik

#### AERODYNAMICS OF PNEUMATIC HIGH LIFT DEVICES

J. von der Decken In AGARD Assessment of Lift Augmentation Devices Feb 1971 36 p refs (See N71-20051 09-02)  
Avail NTIS

An introductory survey of pneumatic boundary layer and circulation control schemes for increasing maximum lift is given. The physical background of boundary layer control by suction and blowing, and of supercirculation and slipstream effects, is described, also the aerodynamic efficiency of the different devices is estimated by theoretical approaches. Finally, practical applications and performance evaluation of pneumatic devices are discussed. Author

**N71-20064#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France), Dept des Etudes de Synthèse.

#### AERODYNAMICS OF VARIABLE SWEEP

Ph. Poisson-Quinton In AGARD Assessment of Lift Augmentation Devices Feb 1971 19 p refs (See N71-20051 09-02)  
Avail NTIS

Aerodynamic problems in the design of variable sweep aircraft are discussed. Selection of pivot location is reviewed, as well as investigations of high lift devices, wing camber, and longitudinal instability near the stall on variable sweep configurations. Application of this configuration to reusable spacecraft is mentioned. E.C.

**N71-20065#** von Karman Inst for Fluid Dynamics, Rhode-Saint-Genese (Belgium)

#### FUNDAMENTAL ASPECTS OF FLOW SEPARATION UNDER HIGH LIFT CONDITIONS

H. P. Horton In AGARD Assessment of Lift Augmentation Devices Feb 1971 19 p refs (See N71-20051 09-02)  
Avail NTIS

A qualitative description is presented of separation problems covering two dimensional laminar and turbulent separation concepts, separated flow on single two dimensional airfoils, boundary layer separation bubbles, separated flow on multi-airfoil systems (wake and boundary layer mixing) and three dimensional separated flow. The possibility of applying theoretical techniques to the prediction of the maximum lift and drag of an airfoil is briefly discussed. E.C.

**N71-20066#** National Lucht En Ruimtevaartlaboratorium, Amsterdam (Netherlands)

#### SOME NOTES ON TWO DIMENSIONAL HIGH LIFT TEST IN WIND TUNNELS

B. van den Berg In AGARD Assessment of Lift Augmentation Devices Feb 1971 18 p refs (See N71-20051 09-02)  
Avail NTIS

Problems associated with two dimensional high lift tests

are discussed in terms of the test setup in the wind tunnel, the design of the models, and the methods to determine the forces on the model. Tunnel wall interference effects are also discussed. These include the effect of the constraint which the tunnel walls impose on the flow as well as the danger of boundary layer separations on the tunnel walls. The necessity of boundary layer control at the model tunnel wall junctions is demonstrated.

Author

**N71-20067#** British Aircraft Corp. Warton (England) Wind Tunnel Dept

**MODEL TESTING REQUIREMENTS AND TECHNIQUES FOR HIGH LIFT SCHEMES: THREE DIMENSIONAL ASPECTS**

C Russell / In AGARD Assessment of Lift Augmentation Devices Feb 1971 22 p refs (See N71-20051 09-02)

Avail NTIS

The subject of three-dimensional high lift model testing is dealt with from the point of view of the development of a specific full-size project. Various topics and problems are dealt with in approximately the order in which they would normally arise from initial concept to data presentation.

Author

**N71-20068#** Boeing Co. Seattle, Wash  
**ANALYSIS OF TRANSPORT APPLICATIONS FOR HIGH LIFT SCHEMES**

L B Gatzert / In AGARD Assessment of Lift Augmentation Devices Feb 1971 23 p refs (See N71-20051 09-02)

Avail NTIS

The way in which the design tradeoff process affects airplane economics is illustrated in relation to the impact of high lift system design on the final configuration selection. An assessment of representative high lift concepts, including boundary layer control, is given in terms of low-speed performance potential. For long-range transport airplanes operating from long runways, it is shown that well-designed mechanical flap systems are generally competitive with more sophisticated concepts involving blowing or suction boundary layer control (BLC). However, recent progress in high lift technology indicates that significant performance gains for long-range airplanes may be possible using BLC techniques. The gains for airplanes designed to operate from shorter fields appear attractive and achievable with today's technology. For STOL airplanes the use of BLC to provide high wing lift together with direct lift from the engines, or a more highly integrated form of lift augmentation such as the jet flap, is mandatory. The interaction between high lift system design and problems involving the stability and control characteristics of the airplane are considered.

Author

**N71-20069#** Breguet-Aviation, Velizy (France) Div Aerodynamique

**ANALYSIS OF COMBAT AIRCRAFT APPLICATIONS FOR LIFT AUGMENTATION DEVICES**

R Tasseire / In AGARD Assessment of Lift Augmentation Devices Feb 1971 21 p (See N71-20051 09-02)

Avail NTIS

Problems associated with the design of high lift systems for combat aircraft are reviewed. Performance and flying qualities are considered. Low level high speed flying requires small wing thickness to chord ratio (about 5 to 7%), high sweep angle (35 to 45 deg), small aspect-ratio (3 to 4) and high wing loadings (about 400 to 600 kg per sq meter). With such a wing, it is difficult to provide good take-off and landing performance for short field operation while maintaining good flying qualities at low speeds. Effective high lift devices are needed to achieve the low stalling speeds required for short takeoff and landing distances and their design must provide a satisfactory level of control in the low speed flight range. The review is intended to clarify the problems encountered in achieving these aims and to indicate ways of solving them.

Author

**N71-20060#** Aeroline and Armement Experimental Establishment, Boscombe Down (England) Performance Div  
**FLIGHT TESTING MILITARY TRANSPORT AIRCRAFT FOR CLEARANCE IN THE STOL ROLE**

K P Eyre / In AGARD Assessment of Lift Augmentation Devices Feb 1971 24 p ref (See N71-20051 09-02)

Avail NTIS

The types of tests which are likely to be required to clear an aircraft from handling and performance aspects for military STOL applications are discussed. Tests made to clear the Andover C Mk 1 are given as an example. No special consideration is given to particular high lift devices each of which may of course introduce individual problems. However, it is considered that in the case of STOL aircraft generally the problem of variability in behavior may require more than usual attention due to the rapid maneuvers and short distances involved with considerable dependence on pilot technique.

Author

**N71-20061#** Rolls-Royce, Ltd., Bristol (England) Bristol Engine Div

**LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE. PART 1: INTERFACE PROBLEMS BETWEEN ENGINE AND AIRFRAME**

J A Hooper / In AGARD Assessment of Lift Augmentation Devices Feb 1971 18 p (See N71-20051 09-02)

Avail NTIS

Interface problems between engine and airframe associated with the achievement of short field performance are described. Civil and military aircraft are treated with the main emphasis on civil STOL. A range of possible lift augmentation devices is considered, and their effect on engine design is shown. The associated problems of noise and performance are also considered. Optimum engine designs and their particular characteristics for various systems are described.

Author

**N71-20062#** Rolls-Royce, Ltd., Bristol (England) Bristol Engine Div

**LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE. PART 2: THERMODYNAMIC PROBLEMS AND SOME POSSIBLE SOLUTIONS**

E A White and H C Hillier / In AGARD Assessment of Lift Augmentation Devices Feb 1971 13 p (See N71-20051 09-02)

Avail NTIS

The effects of the previously established design criteria on the thermodynamics of the engines for STOL applications are discussed. Several possible engine solutions with their associated advantages and disadvantages are described.

Author

**N71-20063#** Lockheed Georgia Co., Marietta  
**OPTIMISING THE PROPULSIVE LIFT SYSTEM FOR TURBOFAN STOL AIRCRAFT CONSIDERING COST EFFECTIVENESS**

H T Bowling / In AGARD Assessment of Lift Augmentation Devices Feb 1971 14 p (See N71-20051 09-02)

Avail NTIS

The results are presented of a comparison of three STOL high lift concepts which have been integrated with bypass-ratio turbofan engines. Transport aircraft configurations optimized using these concepts are compared along with significant characteristics of each system. The purpose of this comparison was to provide possible insight for future studies and testing. None of these systems were subjected to a highly detailed analysis and do not represent completely optimized concepts. Every effort was made to make the comparison as consistent as possible. A secondary purpose is the discussion and demonstration of a study methodology which was developed to integrate cost effectiveness into the early technical development of new airplane concepts. This methodology is primarily applied to a military STOL development program. However, some examples are shown of considerations of commercial cost effectiveness.

Author

**N71-20064#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**A NEW TECHNIQUE FOR AEROFOIL LEADING EDGE STUDIES**

J. Monnerie. In AGARD Assessment of Lift Augmentation Devices Feb 1971 5 p ref (See N71-20051 09-02)

Avail: NTIS

Illustrations are given from an investigation of flow separation bubbles which develop near an airfoil leading edge. These include a drawing of the airfoil profile, a velocity diagram for a profile with a Handley Page slot, a plot of the similarity between the flow on two models, surface flow visualization near the leading edge, boundary layer curves in the bubble region, and water tunnel model visualization data. E.C.

**N71-20065#** Royal Aircraft Establishment, Farnborough (England)  
**SOME COMMENTS ON CHARACTERISTICS OF HIGH LIFT WINGS**

D. N. Foster. In AGARD Assessment of Lift Augmentation Devices Feb 1971 5 p refs (See N71-20051 09-02)

Avail: NTIS

Wind tunnel tests, under as near to two dimensional conditions as possible, were carried out on a wing section with plain leading and trailing edge flaps having boundary layer control by blowing at the flap knees. A range of flap deflections were tested, results are presented for the condition with no leading edge flap deflection and with the trailing edge flap deflection 20 deg. Results suggest that the inviscid lift is achievable with a momentum coefficient which is dependent on the angle of incidence (or the lift), that under these conditions a pressure distribution will be measured which is very similar to the inviscid predictions, and that sensibly zero drag will result. Drag with high lift devices is also discussed. Author

**N71-20066#** Hawker Siddeley Aviation, Ltd., Hatfield (England)

**THE HUNTING H-126 JET FLAP RESEARCH AIRCRAFT**

K. D. Harris. In AGARD Assessment of Lift Augmentation Devices Feb 1971 7 p refs (See N71-20051 09-02)

Avail: NTIS

The jet flap principle is reviewed, as well as the development of a piloted research aircraft to test the principle. Aircraft thrust losses, stability and control problems, and stalling characteristics are discussed. E.C.

**N71-20067#** Canadair, Ltd., Montreal (Quebec)

**AERODYNAMIC RESEARCH ON HIGH LIFT SYSTEMS**

Fotis Mavriplis. In AGARD Assessment of Lift Augmentation Devices Feb 1971 13 p refs (See N71-20051 09-02)

Avail: NTIS

Aspects of two dimensional flow research on high lift systems are discussed. A theoretical method is described for calculating two dimensional potential flow about multi-element high lift airfoils. The method is based on the distribution of vorticity on the airfoil contour. A wall blowing technique is also described which was developed for testing effectively complex high lift models in the wind tunnel. It was used to study the effect of leading edge and trailing edge devices on the aerodynamic characteristics of a 17% and a 10% thick airfoil. Finally, comparisons of calculated and experimental data obtained on some of the complex configurations tested are presented to demonstrate the usefulness of the methods described. Author

**N71-23410#** Advisory Group for Aerospace Research and Development, Paris (France)

**LESSONS WITH EMPHASIS ON FLIGHT MECHANICS FROM OPERATING EXPERIENCE, INCIDENTS AND ACCIDENTS**

Mar 1971 301 p refs. Presented at the 37th Meeting of the

Flight Mech Panel of AGARD, Baden-Baden, 20-23 Oct 1970 (AGARD-CP-78-71) Avail: NTIS HC\$6.00/MF\$0.95

Detailed accident and incident investigations, flight control systems developments and operational performance recordings are used to optimize aircraft flight mechanical parameters. Considerable emphasis is placed on human factors engineering for aircraft safety requirements. For individual titles see N71-23411 through N71-23431.

**N71-23411#** Air Registration Board, London (England)

**A BRIEF REVIEW OF SOME SAFETY STUDIES BASED ON OPERATIONAL FLIGHT RECORDING**

J. C. Chaplin. In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 28 p refs (See N71-23410 12-02)

Avail: NTIS HC\$6.00/MF\$0.95

In order that advances in aviation safety may continue to be made without unnecessarily adding to cost, it is essential to be able to study the effectiveness of current regulations to determine whether or not they are acting in the manner expected. Methods which have been developed to abstract and examine data of safety interest are outlined. The fields of operations and airworthiness are both considered and the relative places of statistical data on the one hand and the more detailed study of isolated events are discussed. Examples are given of some of the results which have been obtained. The importance of the close links which have been developed with the operator is emphasized. Author

**N71-23412#** National Aerospace Lab., Amsterdam (Netherlands)  
**OPERATIONAL FLIGHT RECORDING AND ITS IMPACT ON FLIGHT SAFETY AND AIRCRAFT DESIGN**

T. Van Oosterom. In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 19 p refs (See N71-23410 12-02)

Avail: NTIS HC\$6.00/MF\$0.95

Flight operational experience and results from incident and accident analyses are important sources of basic information for improving flight safety and aircraft design. These sources can be effectively explored by in-flight recording of data, which define the flight condition, the navigational environment and the technical functioning of the aircraft. Present aircraft integrated data systems (AIDS) provide an extensive data acquisition capability and allow for automatic data processing. The main technical features of these systems and the relevant data processing equipment are reviewed from a user's point of view. A survey is given of present and possible future applications of AIDS with emphasis on flight safety and aircraft design data recording. Some specific examples are discussed which illustrate the usefulness of flight recording. Author

**N71-23413#** General Dynamics/Fort Worth, Tex.

**PROVING THE OPERATIONAL CAPABILITY OF A HIGH PERFORMANCE FLIGHT CONTROL SYSTEM**

E. C. Livingston, Jr. In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 12 p (See N71-23410 12-02)

Avail: NTIS HC\$6.00/MF\$0.95

Two generalized approaches to the development and proof of a high performance flight control system are examined. The first approach is conventional in that no more than minimal simulation is utilized to confirm the system analysis and design. In the second approach, extensive use is made of complete closed-loop simulation, including an accurate dynamic model of the airframe, to confirm analysis and design. Examples encountered in the utilization of these two approaches are provided in order to illustrate the benefits of one approach over the other. Experience gained from the utilization of both of these approaches has shown the latter to be the best. The extensive use of flight simulators and an airframe test stand assures that the system will meet requirements after minimal retrofit and flight test. Author



**N71-23414#** Smiths Industries, Ltd., London (England)  
**THE OPERATIONAL PROVING OF AUTOMATIC FLIGHT CONTROL SYSTEMS IN THE APPROACH AND LANDING PHASE**

R. H. Ashforth / In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar. 1971 10 p (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

The Hawker Siddeley Trident aircraft equipped with a flight control system that covers both automatic approaches and automatic landings is studied. The flight control system comprises the SEP 5 autopilot which is triplex in the pitch and roll axis and duplex in yaw. The lessons learnt during the flight trials and also as a result of the service experience are discussed. Changes made to the original design as a result of this experience, applicable to the approach and landing phase, are described in relation to the different levels of clearance. The second part of the paper covers the in-service recording and statistical proving of the automatic landing system. Author

**N71-23416#** Messerschmitt-Boelkow-Blohm G m b H., Munich (West Germany)

**OPERATIONAL PROVING OF AUTOMATIC FLIGHT CONTROL SYSTEMS FOR V/STOL FIGHTER AIRCRAFT**

G. Kissal and H. Schmidlein (Vereinigte Flugtech. Werke G m b H., Bremen, West Germany) / In AGARD Lessons with Emphasis on Flight Mech from Operating Experience Incidents and Accidents Mar. 1971 26 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

Four different types of automatic flight control systems for V/STOL fighter aircraft were flight tested within the past years. The VJ 101 C aircraft makes use of pure jet-thrust-modulation control in the thrust sustained flight regime for rolling and pitching and thrust vector control for yawing. The VAK 191 flying bedstead uses puff-pipe (bleed air) control with additional thrust augmentation for pitching. The main characteristics of the systems are: (1) stability augmentation system with high authority superimposed on the mechanical flight control system versus fly by wire system, (2) integrating control system versus proportional system, (3) pure VTOL versus V/STOL capability, (4) pure thrust modulation control versus puff-pipe control, and (5) puff-pipe control by means of fly by wire with mechanical back up. With all four systems acceptable handling qualities could be reached but it is shown that, especially in case of thrust modulation where the aircraft has nonlinear characteristics, for large control inputs a nonlinear control system gives higher stability. Author

**N71-23418#** Deputy Chief of Naval Operations (Development) Washington, D C

**DESIGN LESSONS LEARNED FROM THE OV-10A BRONCO**

Hugo G. Sheridan / In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar. 1971 13 p (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

The OV-10A Bronco is one of the aircraft designed specifically for low level counterinsurgency warfare. The original design requirements for the aircraft as well as the engineering changes found necessary during the flight test stage are reviewed. Use of the Bronco in combat operations in Southeast Asia is summarized including loss and damage rate. As a result of these combat operations, conclusions are drawn as to the validity of the original requirements for the OV-10A. Design requirements desirable for the next counterinsurgency aircraft in light of the experience in Southeast Asia are recommended. Author

**N71-23417#** Hawker Siddeley Aviation Ltd., Woodford (England)  
**LESSONS FROM OPERATION AND TRIALS OF TWIN TURBOPROP AIRCRAFT ON ROUGH AIRFIELDS**

M. J. Taylor / In AGARD Lessons with Emphasis on Flight Mech from Operating Experience Incidents and Accidents Mar. 1971

13 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

Trials and operations of a civil twin turboprop airliner and of its military counterpart have taken place over a period of nearly ten years. During this time both measured data and operating experience have been accumulated from movements on unprepared airfields. In particular the investigation into two landing accidents involving the civil type has led to performance measurements on grass and hard surfaces. Information is given on the following: (1) undercarriage load measurements, (2) airframe contamination and superficial damage, and (3) aeroplane performance. Author

**N71-23418\*#** National Aeronautics and Space Administration, Washington, D C

**AVOIDANCE OF AIRCRAFT TRAILING VORTEX HAZARDS**

William A. McGowan / In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar. 1971 23 p refs (See N71-23410 12-02)

(NASA TM-X-67125) Avail. NTIS CSCL 01C

Trailing vortices have been the cause of aircraft accidents. Results of accident investigations, theoretical exercises, wind tunnel experiments, and flight tests are used to describe the formation and severity of trailing vortices and the spatial extent of their influence, including factors governing persistence. This information is then used to outline procedures for ready application by pilots, tower operators, and those concerned with the flow of traffic during tactical operations. The procedures provide the necessary appreciation of the physical attributes of trailing vortices, the potential hazards involved when encountering them, and how best to avoid the dangerous portions of the wake during flight operations. Schemes under investigation to monitor remotely both the trailing vortex location and intensity in the airport area and to prohibit formation of high intensity vortices, through aircraft design, are discussed. Author

**N71-23419#** Mississippi State Univ., State College Dept. of Aerophysics and Aerospace Engineering

**THE HANDLING QUALITIES REQUIRED FOR SAFE OPERATION OF SINGLE ENGINE BOUNDARY LAYER CONTROLLED AIRCRAFT IN THE STOL MODE**

S. C. Roberts / In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar. 1971 16 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

Operations of single engine, boundary layer control, STOL aircraft since 1958 are reported. The vehicles have been the high lift, super cub L-21, the modified Cessna L-19, the XA2-1, and the XV-11A with wing loadings ranging from 13 lb/sq ft to 28 lb/sq ft. All of these aircraft had a distributed suction boundary layer control system for lift augmentation and XA2-1 and the XV-11A also had shrouded propellers for static thrust augmentation. The performance, stability and control, and handling qualities of these aircraft have been evaluated and considerable experience gained in the operational aspects of such STOL aircraft with regard to the handling qualities required for safe operation in the STOL mode. Author

**N71-23420#** Breguet Aviation, Velizy (France)

**ESTABLISHING SAFETY MARGINS FOR THE TAKE OFF AND APPROACH OF THE BREGUET 941 [ESTABLISSEMENT DES MARGES DE SECURITE AU DECOLLAGE ET A L'ATTERRISSAGE POUR LE BREGUET 941]**

J. Bastidon / In AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar. 1971 9 p (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

The safety margins to be considered are of the two following types: (1) speed margins (takeoff and approach speed), and (2) fieldlength margins. These two margins are examined and discussed considering the BR 941. Determination of these margins is based

on theoretical considerations, flight measurements and operational test results. Allowance is also made for discussions determining special conditions for civil airworthiness of this airplane. Author

**N71-23421#** Naval Air Systems Command, Washington, D.C.

#### LOW ALTITUDE HIGH SPEED FLIGHT EXPERIENCE

Ralph C. A'Herrah. In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents. Mar. 1971. 13 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

An extensive flight test evaluation of the operational capabilities of contemporary military aircraft in performing low altitude missions is reported. The particular test phase being reviewed, namely the visual target acquisition test, involved 8 aircraft and 200 pilots making more than 400 low altitude sorties. Assigned penetration speeds ranged from 175 to 550 knots. Two altitude corridors were assigned: minimum safe altitude to 400 feet and 500 to 900 feet above the terrain. Author

**N71-23422#** Ecole Nationale Supérieure de l'Aéronautique, Toulouse (France)

#### INFLUENCE OF SIMPLE AERODYNAMIC MODIFICATIONS ON THE PERFORMANCE OF AN AIRCRAFT [INFLUENCE DE MODIFICATIONS AÉRODYNAMIQUES SIMPLES SUR LE COMPORTEMENT D'UN AVION]

J. E. Forestier. In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents. Mar. 1971. 12 p (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

Described are modifications made on prototype Vautour aircrafts during their development phase. Principle difficulties encountered were lateral control and beyond Mach 0.93 longitudinal control characteristics. Adjustments of the turbulence generator positions on the outer airfoils just before the wing tip, and modifications in the chamber of the wing leading edge provided the desired performance improvements. Transl. by G. G.

**N71-23423#** National Aero- and Astronautical Research Inst., Amsterdam (Netherlands)

#### MAN/MACHINE COMBINATION IN THE LIGHT OF SAFETY REQUIREMENTS

F. W. L. Herckenrath, J. J. P. Moelker, and C. M. Ramsey. In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents. Mar. 1971. 10 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

A description is given of a few limiting factors in man and their bearing upon aircraft design. Examples are given of limitations in attention, perception, learning, memory and intelligence, and decision making. Present design deficiencies are considered in the light of crew training and procedures. It is stressed that from the earliest conception of a design close cooperation between designers, safety organizations and prospective operators is of vital importance to assure safety in aerospace operations. Author

**N71-23424#** National Aeronautical Establishment, Ottawa (Ontario)

#### REVIEW OF SEVERAL FACTORS RELEVANT TO JET UPSETS

B. Caiger. In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents. Mar. 1971. 11 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

Various contributory factors to jet upsets are reviewed covering instrument or control system failures and severe turbulence encounters. Related problems of pilot disorientation are discussed. The need for detailed analyses of upsets is emphasized. It is

concluded that well designed autopilot systems may provide more effective control in severe turbulence encounters than the human pilot, but that suppression of primary structural modes and the use of head-up displays are still desirable to alleviate the pilot's difficulties. Author

**N71-23425#** Boeing Co., Seattle, Wash. Commercial Airplane Group

#### APPROACH PATH CONTROL FOR REDUCED NOISE AND IMPROVED TRAFFIC CAPACITY

C. R. Clifford. In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents. Mar. 1971. 22 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

Final approach control for transport aircraft consists primarily in aerodynamic performance during cruise. The specific objectives defined for the Boeing 727 and 737 in this respect, and the boundary layer control research with the 707 prototype, are outlined, together with results achieved. Steep angle, decelerating, and curving approaches have been considered singly and in combination. A simple speed control for decelerating approach on the normal glidepath angle is under development for the 747 and research activities include extending the capability of high quality area navigation equipment to control of flightpath, speed and configuration on final approach so as to minimize noise. Described are the operational characteristics of the airborne system for terminal path guidance on reduced noise trajectories, including the system configuration, functions of key elements, redundancy requirements, control law aspects, and cockpit displays. Author

**N71-23426#** National Aeronautics and Space Council, Washington, D.C.

#### A REVIEW OF V/STOL AIRCRAFT ACCIDENTS IN THE US

John H. Enders and William E. Thurman. In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents. Mar. 1971. 14 p refs (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

V/STOL research and development aircraft accidents have occurred for the same major reasons and over the same operational phase spectrum as have accidents to conventional aircraft. Excluding hover and transition phases from the operational phases, a pattern of accident distribution of V/STOL aircraft is similar to that for conventional aircraft: about 55-60% during landing, about 20% in cruise, and about 20% during takeoff. The pattern of accidents suggests no clearly dominant remedial action to reduce these accidents across-the-board, but increased attention in each of the cause factor areas will effect an improvement. Nearly every accident investigation prompted changes in either design, methods of operation, management structure, pilot training methods, or maintenance procedures. Author

**N71-23427#** Ministry of Defence, London (England)

#### V/STOL IN THE ROYAL AIR FORCE: SOME LESSONS FROM THE FIRST 18 MONTHS

R. G. Lofting. In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents, and Accidents. Mar. 1971. 4 p (See N71-23410 12-02)

Avail. NTIS HC \$6.00/MF \$0.95

Some 18 months of V/STOL operations with the Harrier ground attack and reconnaissance aircraft have been completed and the aircraft's 'light safety record during this period is discussed. The record has been encouragingly good, taking into consideration the novel problems of V/STOL operation and field covered by the complete Harrier flight safety record is not a large one. Selected are the following four topics from the Harrier flight safety record which lie reasonably close to flight mechanics: (1) stability and control; (2) exhaust gas reingestion; (3) ejection facilities; and (4) control system. Author

**N71-23428#** Messerschmitt-Boelkow G.m.b.H. Munich (West Germany).

**V/3V0L ACCIDENTS OR INCIDENTS**

O. Richarz /In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 10 p (See N71-23410 12-02)

Avail. NTIS HC\$6.00/MF\$0.95

Performance tests on two models of the VJ 101C VTOL high performance aircraft are reported and observed accidents connected with flight mechanical aspects are analyzed. Four out of the five accidents reported had something to do with hot gases and recirculation. A great deal of the recirculation problems experienced were directly connected to the triangular arrangement of the aircraft's 6 engines. G.G.

**N71-23429#** Sud-Aviation, Toulouse (France).

**ALL WEATHER SUD/LEAR LANDING SYSTEM INSTALLED ON THE CARAVELLE [SYSTEME D'ATERRISSAGE TOUS TEMPS SUD/LEAR INSTALLE SUR CARAVELLE]**

G. Payeur /In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 10 p (See N71-23410 12-02)

Avail. NTIS HC\$6.00/MF\$0.95

Experience with the all weather SUD/LEAR landing system confirms its reliability in phase 3a automatic approach and landing requirements. The system incorporates a flash warning signal on the panel in front of the flight captain that combines all essential warnings relating to aircraft flight control and integrates in particular the following warnings: (1) HZ-4 and MR-4 indicator flags; (2) beam error detector warnings; (3) autopilot warnings; and (4) altitude error warnings transmitted by the radio altimeter AF-and servo-mechanism unit. The fact that the warnings are combined in a single flash enables the flight captain to continue outside the aircraft and yet perceive within his immediate field of vision a possible malfunction flash signal, he can make a decision (down to 50 ft) to continue the approach or to initiate go-around. Transl. by G.G.

**N71-23430#** Army Aviation Systems Command, St. Louis, Mo.  
**PROBLEMS ENCOUNTERED IN NAP OF THE EARTH FLYING AND THEIR EFFECT ON AIRCRAFT DESIGN MISSION PERFORMANCE**

Lawrence R. Dewey, Jr. /In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 5 p refs (See N71-23410 12-02)

Avail. NTIS HC\$6.00/MF\$0.95

Reviewed are some of the design problems that are accentuated by tactical helicopter maneuvering close to ground. Considered are aerodynamic coupling effects that cause the aircraft to roll during climb with sudden forward pitching for a gun run on target, and dynamic structural aircraft vibrations during low level high speed terrain avoidance maneuvers. Proposed safety measures include an automatic information and warning system for the pilot and safety margins that realistically encompass fatigue dynamics inherent in close to ground operations. G.G.

**N71-23431#** Ministry of Technology, London (England)

**WEATHER AS A FACTOR IN FATAL ACCIDENTS INVOLVING CIVIL TRANSPORT AIRCRAFT**

J. Burnham /In AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 21 p refs (See N71-23410 12-02)

Avail. NTIS HC\$6.00/MF\$0.95

An analysis is given of the importance of weather in fatal accidents involving civil transport category aircraft during the period 1946-69. Out of a total of 1,433 accidents involving 25,801 fatalities, weather is known to have been a factor in 318 accidents involving 6,778 fatalities, and may have been involved in others. The average of 13 accidents per year in which weather was involved comprise about 10 per year in poor visibility, 2 per year

due to gusts and 1 per year due to icing and other weather hazards. The only type of weather accident which has increased in frequency in recent years is that of approach and landing in poor visibility. Author

**N71-25080#** Advisory Group for Aerospace Research and Development, Paris (France).

**EXTREME VALUE ANALYSIS AND ITS APPLICATION TO c. g. VERTICAL ACCELERATIONS MEASURED ON TRANSPORT AIRPLANES OF TYPE C-130**

Otto Buxbaum (Lab. fuer Betriebsfestigkeit) Mar 1971 31 p refs. Presented at 31st Meeting of the Panel on Environ. Statist. Data of AGARD, Tonsberg, Norway, 1-6 Nov. 1970 (AGARD-R-579-71) Avail. NTIS

The interpretation of cumulative frequency distributions of measured flight loads can be increased significantly by an additional extreme value analysis. This method not only leads to a higher reliability in fatigue design but may be used also for a prediction of extreme loading conditions and for a description of the effect of airplane and flight parameters on loads, as is demonstrated for c.g. vertical accelerations and gust velocities measured on airplanes of type C-130. Author

**N72-11915#** Advisory Group for Aerospace Research and Development, Paris (France)

**HELICOPTER GUIDANCE AND CONTROL SYSTEMS**

Sep 1971 261 p refs. Partly in ENGLISH and partly in FRENCH. Presented at the 12th Meeting of the Guidance and Control Panel of AGARD, Konstanz, West Germany, 7-9 Jun 1971.

(AGARD-CP-86-71) Avail. NTIS

Papers on military helicopter technology are presented. The topics covered include helicopter requirements, system operation and integration, subsystems, advanced developments, and test results and operational experience. For individual titles, see N72-11916 through N72-11939.

**N72-11916#** Defense Dept., Washington, D.C.

**UNITED STATES ARMY HELICOPTER EXPERIENCES AND FUTURE REQUIREMENTS**

Conrad L. Stansberry /In AGARD Helicopter Guidance and Control Systems Sep 1971 6 p (See N72-11915 03-02)

Avail. NTIS

The U.S. Army has found the helicopter to be an extremely versatile vehicle in performing all functions of combat. It has been integrated into organizations throughout the Army force structure. The concepts of airmobility have been validated during combat operations in a counterinsurgency environment in Vietnam. At this time, the U.S. Army is in a period of transition requiring an assessment of the applicability of the airmobile concept in the mid and high intensity warfare environment. To improve the existing capability, new helicopters and evaluations of different types of units with organic airmobile elements to optimize the effectiveness of our combat units must be developed. It is expected that the concepts of airmobility warfare brought to fruition with the advent of the helicopter and applied so successfully in Vietnam can be applied with equal success on other battlefields in other areas in the future. Author

**N72-11917#** Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany)

**OPTIMIZATION OF AUTOMATIC FLIGHT CONTROL CONCEPTS FOR LIGHT HELICOPTERS WITH ALL WEATHER CAPABILITY**

H. Koenig and H. Schmitt /In AGARD Helicopter Guidance and Control Systems Sep 1971 13 p refs (See N72-11916 03-02)

Avail. NTIS

All-weather equipment of minimum complexity for light helicopters is presented. The criteria for its selection include

mission performance requirements as well as consideration of weight, complexity and cost. The special features of a helicopter with hingeless rotor are discussed. The flight control system being developed is shown by a step-by-step process up to an optimal equipment for civilian and military application in all-weather flight. This report presents the validation of flight control systems of SAS and ASE performance level. Successful flight tests of the Ferranti FAS2 and the BSW-FRG 14 flight control equipment have been conducted on the helicopter MB8-BO 105. Good agreement has been found between theoretical and simulation studies. The systems can be used for many important military purposes. Author

**N72-11918# Service Technique Aeronautique, Paris (France)  
FLIGHT SAFETY WITH AUTOMATIC CONTROL: REQUIREMENTS AND IMPLEMENTATION [LA SECURITE DU VOL EN PILOTAGE AUTOMATIQUE EXIGENCES ET REALISATIONS]**

A Guibaud and D Autechaud. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 6 p. In FRENCH (See N72-11915 03-02)  
Avail. NTIS

The breakdown of automatic pilots or auxiliary stabilization systems may have grave consequences for helicopter flight, since these aircraft often operate at low altitudes. Safety requirements constitute one part of a theoretical study of breakdowns, requirement implementation and testing were also studied. A probability analysis of simple and double breakdowns was undertaken. In the case of active breakdown of the automatic pilot, it is necessary to limit the rapid evolution of the apparatus and thus to increase the time allowed to the pilot to react and resume manual flight control. Surveillance devices are necessary on the automatic pilot in order to detect active breakdown and to rapidly suppress the erroneous command. Such compatibility and threshold devices are available on the Puma and Alouette 3 aircraft. Finally, surveillance of the flight control chain, from detectors to servo-command, can be done internal organization of the automatic pilot, extending the possibilities for surveillance devices without increasing cost. Transl. by K.P.D.

**N72-11919# Royal Aircraft Establishment, Farnborough (England)  
THE IMPLICATIONS OF OPERATING HELICOPTERS IN POOR VISIBILITY**

J E Nethaway. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 20 p. refs (See N72-11915 03-02)  
Avail. NTIS

A method of weather minima calculation is proposed for small sites and is extended to allow an estimate to be made of the instrument or automatic approach performance requirements if the weather minima are to be achieved. As an example of the estimation technique an assumption is made of a 6 deg approach path coupled with a 60 kn (111 km/h) approach speed and it is suggested that 120 ft/700 yd (36m/640m) weather minima should be attainable. The equipment requirements necessary to achieve the weather minima are considered and possible developments for the future are discussed. The future developments could include improved displays based on cathode ray tubes, and also various levels of automatic flight path control. A radio/radar guidance aid is required and the overlap between it and the visual guidance system is discussed. The approach and landing system described implies a weight penalty, the extent of which depends on the severity of the weather to be overcome. With this in mind a tentative estimate is made of the equipment weight which may be necessary to achieve various weather minima. Finally, a study has been made of the statistical occurrence of low visibility in the UK from which it has been deduced that, for the approach conditions assumed, a helicopter should be able to complete approaches to land on about 98% of occasions in the year. Author

**N72-11920# Air Force Systems Command, Wright-Patterson AFB, Ohio. Air Force Flight Dynamics Lab.  
PROGRESS OF THE USAF HELICOPTER PROGRAM: LOW**

**SPEED CONTROL TO LANDING ON INSTRUMENT IN HELICOPTERS**

Charles A Scolatti. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 15 p. refs (See N72-11915 03-02)  
Avail. NTIS

A functional flight control-display system is described which provides the small and medium sized helicopter a manual-on-instrument capability from take-off to landing. The display solution is based upon extending the capability of the flight director as it is employed today in helicopters for flying fixed wing type profiles to encompass the unique portion of the low speed regime. With respect to automatics, pilot workload has been reduced and control maneuverability enhanced by introducing innovations to the design of stability augmentation systems in the yaw and collective channels. The flight control-display system was developed using beam guidance in anticipation of the upcoming guidance system proposed by the SC-117 Committee. Testing of the system elements is complete. Evaluation of the synthesized system will be completed by the end of the year. Work is beginning on having user command personnel test the system in its applied form on two UH-1N helicopters at the USAF Instrument Pilot Instructors School. Author

**N72-11921# Ambar Industries, Inc., Garden City, NY. Arms Div.**

**AN OPTIMUM MILITARY HELICOPTER NAVIGATION SYSTEM**

Marvin Taylor. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 11 p. refs (See N72-11915 03-02)  
Avail. NTIS

A low-cost, all-weather, self-contained navigation system was studied in order to fully exploit the many military capabilities of helicopters. Inertial, Doppler-Magnetic, and Doppler-Gyroscopic Navigation systems are analyzed to determine parametric requirements (such as gyro drift, torque scaling, and computer requirements) as a function of navigation accuracy. A study of these alternate candidate systems indicates an optimum approach is the combination of Doppler velocity with an accurate heading indicator utilizing low drift gyroscopes that can rapidly gyro-compass to true North during ground alignment. For subsonic application less precise gyro drift is required with this approach than for an equivalent all-inertial system. The various system configurations are functionally defined and cost vs performance analysis using typical parameters is performed for the alternate candidate systems. Author

**N72-11922# Bodenseewerk Geraetetechnik GmbH, Ueberlingen (West Germany)**

**SOME PROBLEMS IN THE DEVELOPMENT OF AN AUTOMATIC FLIGHT CONTROL SYSTEM FOR LIGHT HELICOPTERS**

W Wellern. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 15 p. refs (See N72-11915 03-02)  
Avail. NTIS

Some of the problems and their solution are discussed arising in the development of an automatic flight control system for light helicopters. The control system is the FRG 14/Stub. The cross coupling between the axes makes it essential to regard the helicopter control as multiloop control and to take account of all six degrees of freedom of the vehicle. These investigations were done with the aid of a program drawn up recently for analysis applied first to a light helicopter which is equipped with a hingeless rotor (BO 105). This type of rotor shows very high control effectiveness and very fast reactions to control inputs. Thus it seems to be necessary to include the nonlinearities of actuators and hydraulic booster in the investigation and to perform a simulation on the analog computer. Here the problem of limit cycles due to backlash arises. The limit cycles are reduced by means of special nonlinear networks so that they are no longer perceived by passengers. Development of the FRG 14 System was continued by hardware simulation and concluded with good results in flight tests. Author

**N72-11923# Siemens A.G., Munich (West Germany)  
DIFFERENCES AND COMMONALITIES IN HELICOPTER**

**AND FIXED WING DOPPLER SENSOR TECHNOLOGY**

K Maarz /in AGARD Helicopter Guidance and Control Systems  
Sep 1971 5 p refs (See N72-11915 03-02)

Avail NTIS

The possibilities and limitations of rotary and fixed wing compatible Doppler sensor designs are discussed. Measurement of velocities near zero at often relatively high values for the drift angle is a requirement for helicopters only. For fixed wing aircraft on the other hand operation at high altitudes at high speeds influence antenna and transmitter design. The lower mean speeds in helicopters put more weight on these measurement errors, which are constant relative to velocity, whereas in fixed wing aircraft in most cases measurement errors dominate which are proportional to velocity. In helicopters and VTOL aircraft fixed antenna installation is generally preferred. Whereas the use of noncoherent pulse systems is limited to fixed wing aircraft, continuous wave and FM Doppler sensors are successfully used in helicopter navigation systems. Author

N72-11924# Teledyne Systems Co., Northridge, Calif.

**AN INTEGRATED LOW ALTITUDE FLIGHT CONTROL SYSTEM FOR HELICOPTERS**

James P. Murphy, Herman L. Walker, and Lawrence A. Kaufman /in AGARD Helicopter Guidance and Control Systems Sep. 1971 20 p refs (See N72-11915 03-02)

Avail NTIS

After a brief introduction that highlights the need for the system and some design philosophies, the basic concepts for low altitude flight are presented indicating the modes of flight employed by IHAS: terrain following (TF), and terrain avoidance (TA). This is followed by a dissertation on the functional approach used to provide the relatively high degree of TF capability required. Block diagrams are utilized to identify the system sensors, central computer and output devices, i.e., displays and flight controls. Prior to a discussion of the equations solved by the central digital computer, the equipment mechanization is briefly described to familiarize the reader with the IHAS equipments. A commentary is presented on the setup and results of a simulation of the automatic TF system and is followed by a description and limited listing of results of the IHAS flight test program. It is shown that the high degree of TF capability provided agreed very well with the results predicted by analysis and simulation. Finally, some concluding remarks are provided to identify the significant accomplishments of the IHAS low altitude control system development. Author

N72-11925# Singer-Kearfott, Pleasantville, N.Y.

**OPERATIONAL CONSIDERATIONS AND APPLICATIONS OF THE TALAR(R) 4 LANDING AID TO HELICOPTERS**

R. Mohol and J. Taylor /in AGARD Helicopter Guidance and Control Systems Sep 1971 13 p refs (See N72-11915 03-02)

Avail NTIS

The requirements of helicopter operations are discussed for using the Talar 4 system, currently in operational use by the United States Air Force to provide a portable landing aid for fixed wing tactical transport aircraft. The Talar 4 ground station characteristics are presented with helicopter flight test evaluations in Europe. It is concluded that the Talar 4 system is capable of meeting tactical helicopter operational requirements. F.O.S.

N72-11926# Aeronautical Systems Div., Wright-Patterson AFB, Ohio

**AUTOMATIC APPROACH AND HOVER COUPLER FOR HH-53 HELICOPTERS**

Robert A. Andes /in AGARD Helicopter Guidance and Control Systems Sep 1971 7 p refs (See N72-11915 03-02)

Avail NTIS

The Automatic Approach and Hover Coupler which provides the HH-53 rescue helicopter with the capability to automatically transition from forward flight, anywhere within the HH-53 flight envelope, to a hover over flat or rolling terrain, independent of gross weight and center of gravity is discussed. The approach coupler design is based on an approach trajectory characterized

by a constant longitudinal deceleration of 8 knots/seconds and a constant rate of descent of 300 feet/minute until a groundspeed of 40 knots is reached. At this point the rate of descent is reduced to 100 feet/minute. The hover coupler provides altitude retention within  $\pm 3$  feet and zero knot groundspeed within  $\pm 1.5$  knots of the Doppler radar measured velocity. A hover trim control is also provided to permit a limited repositioning of the aircraft by the pilot/copilot/crewman during the rescue operation. The couplers satisfactorily completed environmental qualification tests at Sikorsky Aircraft Company, Stratford, Connecticut, and operational test and evaluation by the Military Airlift Command, Eglin Air Force Base, Florida. Author

N72-11927# Army Electronics Command, Fort Monmouth, N.J.

**TERRAIN AVOIDANCE RADAR FOR US ARMY**

Otto H. Schoenberger /in AGARD Helicopter Guidance and Control Systems Sep 1971 14 p refs (See N72-11915 03-02)

Avail NTIS

The objectives and the conduct of the U.S. Army's development program are reported for providing a terrain avoidance/terrain following capability for Army rotary-wing aircraft. The over-all program goals are described. Control aspects of helicopters were considered in light of TA/TF requirements with an immediate realization of their importance in any TA/TF application. As such, the control system was developed first, including terrain following command computation and coupling provision to the flight control system. A unique method of in-flight simulation of terrain and radar sensor was conceived. This airborne terrain and radar simulator allows full in-flight evaluation of the control system, and offers unlimited flexibility as to the type of terrain over which the system is to be tested without subjecting the aircraft and crew to the hazards of testing a control system in close proximity to terrain. A variable parameter terrain avoidance radar is described to replace the terrain and radar simulator after initial evaluation of the control system. The primary objective for this radar was to provide a terrain sensor with technical flexibility sufficient to allow TA/TF performance evaluation over the complete performance spectrum, ranging from simple fixed beam manual terrain following to sophisticated simultaneous terrain following and terrain avoidance, using transverse profile type display and coupling into the flight control system. Technical details of the radar design are given, including selection of the parameters. Author

N72-11928# Royal Aircraft Establishment, Farnborough (England).

**THE EFFECTS OF SEMIRIGID ROTORS OF HELICOPTER AUTOSTABILISER DESIGN**

H. B. Johnson /in AGARD Helicopter Guidance and Control Systems Sep 1971 13 p refs (See N72-11915 03-02)

Avail NTIS

Theoretical studies carried out into the basic problems posed by 'semi-rigid' rotor designs are described, and the directions in which automatic stabilizers for these aircraft are likely to develop are indicated. Two problems in particular were examined, viz the pitching instability with angle of attack and forward speed, and the interaction between aircraft of motion and those of the rotor dynamics. The latter problem is concerned with the rolling motion termed the 'pendulum' mode resulting primarily from the increased coupling between fuselage and rotor. It is shown that a potential resonance between the 'pendulum' mode and the in-plane blade motion exists. Means of avoiding this by suitable design of the autostabilizer are suggested. Author

N72-11929# Societe Nationale Industrielle Aerospatiale, Paris (France)

**AN AUTONOMOUS NAVIGATION SYSTEM FOR HELICOPTERS [SYSTEME DE NAVIGATION AUTONOME POUR HELICOPTERES]**

M. Fourcade /in AGARD Helicopter Guidance and Control Systems Sep 1971 8 p In FRENCH (See N72-11915 03-02)

Avail NTIS

An autonomous navigation system which was developed for the SA-330 helicopter is described. A discussion of the components, functions, and essential characteristics of the system is presented. Flight test methods are considered for utilization in performance determination. Transl. by K.P.D.

**N72-11930#** Elliott Flight Automation, Ltd., Rochester (England). Flight Controls Div.

**SOME DESIGN ASPECTS OF THE STABILITY AUGMENTATION SYSTEM FOR THE WG13 RIGID ROTOR HELICOPTER**

D. Sweeting /in AGARD Helicopter Guidance and Control Systems Sep 1971 12 p (See N72-11915 03-02)  
Avail: NTIS

Some features of the AFCS designed for the Anglo-French WG13 rigid rotor helicopter are described and in particular those arising from the concept of a modular multi-role helicopter, designed both for high speed maneuverable flight at low altitudes and for operation in tightly controlled autopilot modes. A brief description of the system configuration including redundancy, safety features, sensors, and actuation system is given together with an indication of system size and weight, and electronics technology employed. The design requirements for the pitch stability augmentation system (SAS) are examined in relation to the conflicting requirements for low SAS authority for safety against the high control gains combined with large attitude changes required for stability and maneuverability. The concept of a collective autostabilizer independent of the pitch SAS is introduced which alleviates these design problems of the pitch channel and reduces considerably the effects of a pitch runaway. The design of the roll SAS channel is similarly influenced by the requirement for stability at high angles of bank during maneuvers while using the minimum of control authority; a type of roll rate demand system designed to operate over a wide range of bank angle is described together with the control system developed for the yaw axis. Author

**N72-11931#** United Aircraft Corp., Stratford, Conn. Avionics, Control and Support Systems Branch

**A FEASIBLE FEEL AUGMENTATION SYSTEM FOR HELICOPTERS**

Harold S. Oakes /in AGARD Helicopter Guidance and Control Systems Sep 1971 7 p (See N72-11915 03-02)  
Avail: NTIS

A description and evaluation are given of the feel augmentation system (FAS). The FAS differs from most traditional automatic flight control systems in that, instead of augmenting the pilot's input to the control system by providing swash plate motion to stabilize the helicopter, it introduces only forces on the pilot's hand. If the pilot resists these forces, he then experiences the feel desired for continuing the maneuver he has started. If he does not resist the force, the stick will move and stabilize the aircraft so that it will stay in steady state trimmed flight. An extensive flight evaluation of the system in a CH-53A indicated a significant improvement in the handling qualities of the helicopter at high speeds, and that the aircraft could be maneuvered precisely at all airspeeds, permitting the pilot to use the entire V-N envelope. D.L.G.

**N72-11932#** Societe Francaise d'Equipments pour la Navigation Aeriennne, Neuilly-sur-Seine (France). Dept. Pilotage Helicopters.

**STABILITY AUGMENTATION SYSTEMS (SAS) [LES SYSTEMES D'AUGMENTATION DE STABILITE (SAE)]**

Henrot /in AGARD Helicopter Guidance and Control Systems Sep 1971 5 p. In FRENCH (See N72-11915 03-02)  
Avail: NTIS

A simple system for increasing helicopter stability is discussed. The components of the calculator and jack are described. Transl. by K.P.D.

**N72-11933#** Princeton Univ., N.J. Dept. of Aerospace and Mechanical Sciences

**HELICOPTER IFR FLIGHT PATH CONTROL SYSTEM**

Theodor A. Dukes /in AGARD Helicopter Guidance and Control Systems Sep 1971 10 p refs (See N72-11915 03-02)  
(Contract DA-28-043-AMC-02412(E))  
Avail: NTIS

Various aspects of piloted flight path control, including positioning, are discussed according to their significance in making decisions about the structure of the control system. The translational loop requirements, the choice of a nominal error coordinate system, and a discussion of the pilot's role, lead to a control system in which errors and error rates are displayed explicitly and the pilot uses essentially acceleration control in his main effort to control error rates or velocities in three dimensions. An integrated display contains all the information needed for the continuous loop closures. The proposed system is applicable to trajectory control in general so that considerable commonality in flying various tasks can be achieved. Author

**N72-11934#** Army Electronics Command, Fort Monmouth, N.J. Avionics Lab.

**PRECISE IFR HOVERING: AN OPERATIONAL NEED AND A FEASIBLE SOLUTION**

William P. Keane and R. Joseph Milelli /in AGARD Helicopter Guidance and Control Systems Sep 1971 9 p (See N72-11915 03-02)  
Avail: NTIS

A man-machine simulation program was conducted which indicates the feasibility of developing an IFR hover capability with state-of-the-art sensors, controls and displays. Display alternatives included a simple hover indicator, a flight director and a fully integrated multi-colored CRT display. Control alternatives for the CH-54 aircraft included the CH-54 ASE and two alternate systems employing load cable information feedback and velocity feedback. IFR hover was shown to be a reasonable task from a pilot workload standpoint. Displays and controls couple strongly in finding the best solution. A wide range of performance was achieved with the best systems providing a hover accuracy of 1-2 feet. All tests were performed under simulated gust conditions. A formal analysis of variance was performed on the data. These results indicate the feasibility of accomplishing more precise construction and logistical tasks by the helicopter in the near future through the use of instrument hover. The unloading of containerized ships by the helicopter is a possible application with both commercial and military advantage. Author

**N72-11935#** Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany)

**ADVANCED DOPPLER INERTIAL NAVIGATION SYSTEM FOR TRANSPORT HELICOPTER**

V. Krogmann /in AGARD Helicopter Guidance and Control Systems Sep 1971 14 p refs (See N72-11915 03-02)  
Avail: NTIS

Conventional ground and in-air gyrocompassing techniques together with Doppler-inertial navigation are treated briefly. Main attention is paid to optimal ground and in-air alignment and Doppler-inertial-mixing. As far as the optimization is concerned, Kalman filter technique with a ten to fourteen element state vector is compared to a simple digital filter-technique based on recursive or non-recursive least squares. Comparison between the least-square-technique and the Kalman-filter shows that their respective performance is roughly in the same order of magnitude without position fixes. The least-square-technique is recommended because its airborne computer requirements are by far lower than the Kalman-filter loading. This technique, as well as the Kalman-filter has the ability to recover the position error caused by initial misalignment and the performance does not depend on the magnitude of the initial misalignment. The proposed system is based on the least-square technique. Assuming a 2-3 minutes ground alignment, the operational sequence for in-air alignment and Doppler-Inertial Navigation is described. The computer loading for both the ground and in-air alignment of this system is considered. Author

**N72-11936#** Mullard Research Labs., Redhill (England)  
**DESIGN AND EVALUATION OF A HELICOPTER GUIDANCE AID** c21

R. N. Alcock, D. Alter, S. J. Robinsin, and R. P. Vincent. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 4 p. (See N72-11915 03-02)  
 Avail. NTIS

A description of the microwave aircraft digital guidance equipment (MADGE) system is given. The system is designed as an approach aid for V/STOL and fixed wing aircraft and is particularly suited for military tactical applications and for use by helicopters. A typical MADGE ground installation comprises three man-portable units: (1) an azimuth approach angle measuring unit incorporating a transponder and means for encoding azimuth and elevation measurements; (2) an elevation or glide-slope angle measuring unit; and (3) an azimuth missed approach angle measuring unit. In the aircraft there is a control panel, on which the approach data may be set by the pilot, and a transmitter-receiver, with circuits for distance measurement and for decoding the angle information. In civil applications the approach path can be pre-set for individual aircraft types. One or two monopole aerials, depending on aircraft aerial siting and observation problems, are used to give wide angle coverage. D L G

**N72-11937#** Honeywell, Inc. Minneapolis, Minn.  
**FLIGHT TEST OF A HYDROFLUIDIC THREE-AXIS DAMPER ON A HELICOPTER**

R. A. Evans and G. W. Fosdick. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 12 p. refs. (See N72-11915 03-02)  
 Avail. NTIS

Tests were conducted on a fixed-gain, three-axis hydrofluidic stability augmentation system (FSAS) in a UH-1C helicopter. The FSAS used a vortex rate sensor, two or more stages of amplification, and various shaping networks (lag, lag/lead, and high-pass) in each of the three axes, all mechanized with hydrofluidics. The system was designed, developed, bench tested and qualified for the environment. Reliability testing previously conducted estimated MTBF at 83,000 hours per axis (excluding servoactuator). Flight test results indicate pilot approval, operation over all airspeeds including hover, and excellent handling qualities. The FSAS performance was rated as better than that of the mechanical stabilizer bar by the pilots. Predicted high reliability was supported by a 60-hour, trouble-free fluidic controller operation. Author

**N72-11938#** Computing Devices of Canada, Ltd., Ottawa (Ontario)  
**PROJECTED MAP NAVIGATION IN MILITARY HELICOPTERS: APPLICATIONS AND OPERATIONAL EXPERIENCE**

R. I. MacNab and J. C. Alexander. In AGARD Helicopter Guidance and Control Systems. Sep 1971. 10 p. refs. (See N72-11915 03-02)  
 Avail. NTIS

Extensive flight experience has confirmed the feasibility of the projected map navigation systems (PMS) as ideally suited for military tactical aircraft, particularly helicopters. The reasons for this conclusion are explained in detail, and by documented comment from flight trial reports. The basis for concluding that the PMS are fundamentally superior to present day conventional navigation systems is also explained. In addition, a recommendation is made for implementing a particular projected map system which has been developed to the flyable prototype stage. D L G

**N72-11939#** Centre d'Essais en Vol, Bretigny-Sur-Orge (France)  
**EXPERIENCE OF THE FRENCH FLIGHT TEST CENTER IN ALL-WEATHER HELICOPTER LANDING [EXPERIENCE DU CENTRE D'ESSAIS EN VOL FRANCAIS DANS LE DOMAINE DE L'ATERRISSAGE TOUT TEMPS SUR HELICOPTERE]** c21

P. Bloch. In AGARD Helicopter Guidance and Control Systems

Sep 1971. 6 p. In FRENCH. (See N72-11915 03-02)  
 Avail. NTIS

Approach and landing under bad visibility conditions was the object of numerous tests for more than ten years. The performance and safety of systems was evaluated with an eye to their certification. A five-year study on the utilization of a radioelectronic rectilinear array for helicopter guidance is discussed. Transl. by K. P. D.

**N72-15958#** Advisory Group for Aerospace Research and Development, Paris (France).

**OPTIMALITY CRITERIA IN STRUCTURAL DESIGN**  
 W. Prager (Brown Univ.) Dec 1971. 16 p. refs.  
 (AGARD-R-589-71) Avail. NTIS

The derivation of optimality conditions from extremum principles of structural theory is reviewed, with special emphasis on conditions for global optimality. Following a brief introduction, the optimal design of sandwich structures is discussed for a single behavioral constraint and for multiple constraints. Structural elements with solid sections are dealt with in a separate section. In addition, a three-dimensional problem is investigated that includes many problems of optimal structural design as special cases. A final section presents the previously considered optimality criteria in a unified way that frequently suggests the form of optimality conditions in new situations. Author

**N72-20976#** Advisory Group for Aerospace Research and Development, Paris (France).

**FLIGHT TEST TECHNIQUES** AGARD Conference Proceedings. Feb. 1971. 239 p. refs. Papers presented at the 38th Meeting of the Flight Mechanics Panel of AGARD, Toulouse, 10-13 May 1971.  
 (AGARD-CP-85) Avail. NTIS

The proceedings of a conference on aircraft flight test techniques are presented. Subjects discussed are: (1) stability and control tests with emphasis on supersonic and V/STOL aircraft; (2) performance measurements of extremely fast aircraft; (3) gliding reentry vehicle tests; (4) aircraft carrier operational suitability tests; and (5) evaluation of air breathing propulsion systems. Data reduction for determining the aerodynamic characteristics of aircraft and comparison with wind tunnel test results are emphasized. The views of personnel from test pilot schools regarding flight test procedures are included. For individual titles, see N72-20977 through N72-20986.

**N72-20977#** Boeing Co., Seattle, Wash. Flight Test Engineering - Operations.

**STABILITY AND CONTROL 747 FLIGHT TESTING**  
 D. D. Archer. In AGARD Flight Test Tech. Feb. 1972. 12 p.  
 (See N72-20976 12-02)  
 Avail. NTIS

The basic development and FAA certification flight test program of the 747 aircraft was conducted using five test airplanes in an intensive program involving 1443 flight hours and a total of 10-2/3 months of flight testing. Each airplane was instrumented to perform assigned tasks, and sufficient duplication in instrumentation was provided to allow flexibility in re-assigning tests for schedule changes due to development contingencies. Stability and control tests were conducted on four of the airplanes and consisted of 80 hours of development tests and 72 hours of FAA tests for a total of 162 hours. In addition, airplane handling characteristics have since been evaluated by certification authorities of Great Britain, France, and Germany. All pilots who have participated in the test programs have judged the flight handling characteristics as excellent. Author

**N72-20978#** Aerospatiale Usines de Toulouse (France).  
**METHODS OF UTILIZING THE RESULTS OF FLIGHT TESTS FOR THE STUDY OF FLIGHT PERFORMANCE OF THE CONCORDE SUPERSONIC TRANSPORT [METHODES D'UTILISATION DES RESULTATS D'ESSAIS EN VOL POUR**

**L'ETUDE DES QUALITES DE VOL DE L'AVION DE TRANSPORT SUPERSONIQUE CONCORDE]**  
R. Deque and C. Pelegatti / In AGARD Flight Test Tech. Feb. 1972 18 p In FRENCH (See N72-20976 12-02)  
Avail: NTIS

The classic parameters of flight mechanics recorded onboard the Concorde are compared to those obtained by simulation. Data cover aerodynamic limitations, stability and control systems, and instrument performance. Also given are the flight parameters used to study the flight qualities and the mathematical models used to determine them. Results show small differences in form and precision accuracy of the two methods. Transl. by E.H.W.

**N72-20879#** Air Force Flight Test Center, Edwards AFB, Calif.  
**AN APPROACH TO STALL/SPIN FLIGHT TEST OF MANEUVERING-TYPE AIRCRAFT**  
Collet E. McElroy / In AGARD Flight Test Tech. Feb. 1972 6 p refs (See N72-20976 12-02)  
Avail: NTIS

Procedures for modifying the conventional stall and spin type of flight tests on high performance aircraft are presented. Specific aspects of the stall and spin tests are: (1) evaluation of natural/artificial stall warning that indicates the approach of maximum usable lift, (2) determination of the angle of attack for maximum usable lift, (3) evaluation of natural/artificial loss-of-control warning and tests of departure prevention device, and (4) determination of all possible out-of-control events and effective recovery techniques. Examples of the control application and stall/departure entry conditions for four conditions are detailed. Author

**N72-20880#** Hawker Siddeley Aviation, Ltd., Kingston upon Thames (England).  
**THE HARRIER - SOME ASPECTS OF V/STOL STABILITY AND CONTROL FLIGHT TESTING**  
R. J. Balmer / In AGARD Flight Test Tech. Feb. 1972 11 p refs (See N72-20976 12-02)  
Avail: NTIS

The dynamic stability of V/STOL aircraft in general and a description of the aerodynamic characteristics of the P-1127 aircraft are presented. The techniques used for the initial hovering and transition flights of the P-1127 are described. The development of the Harrier aircraft from the P-1127 configuration is discussed. Examples are given of some of the special stability and control techniques used during development of the Harrier aircraft. Special cockpit instruments and onboard flight data recorders are described. Author

**N72-20881#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).  
**FLIGHT TESTS OF THE PERFORMANCE OF THE DO-31 AIRCRAFT [ESSAIS SUR LES QUALITES DE VOL DU DO 31]**  
G. Dragenow / In AGARD Flight Test Tech. Feb. 1972 9 p In FRENCH (See N72-20976 12-02)  
Avail: NTIS

A description is given of the program used to analyze the flight characteristics of the VOTOL aircraft DO-31. Studies were made of the principles of control and stability and the traits of large and small flying tests. Tests for a prototype DO-31E, are included. Transl. by E.H.W.

**N72-20882#** Aerospatiale Usines de Toulouse (France).  
**MEASURE OF PERFORMANCE. METHODS OF ANALYSIS AND APPLICATION TO THE CONCORDE [MESURE DES PERFORMANCES. METHODES D'ESSAIS EN VOL APPLIQUEES A CONCORDE]**  
J. Touraille and R. Langlade / In AGARD Flight Test Tech. Feb. 1972 19 p In FRENCH (See N72-20976 12-02)  
Avail: NTIS

The principle test methods utilized in aerospace to measure the performance of the Concorde aircraft are presented. Data

cover operational performance, takeoff and landing trajectories, and the precision of instruments necessary to calculate performance. Transl. by E.H.W.

**N72-20883#** National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif.  
**TECHNIQUES FOR THE EVALUATION OF AIR-BREATHING PROPULSION SYSTEMS IN FULL-SCALE FLIGHT**  
Donald R. Bellman, Frank W. Burclam, Jr., and Norman V. Taiton / In AGARD Flight Test Tech. Feb. 1972 15 p refs (See N72-20976 12-02)  
(NASA-TM-X-68306) Avail: NTIS CSCL 21A

Techniques for evaluating air breathing propulsion systems in full scale flight are discussed. Examples of flight test techniques being used to measure the performance of turbojet propulsion systems are presented. Included are the determination of jet engine thrust, the study of inlet pressure phenomena, the measurement of exhaust nozzle characteristics, and the use of tufts at supersonic speeds. A flow diagram of a gas generator method of thrust calculation is illustrated. Author

**N72-20884#** Centre d'Essais en Vol, Bretigny-sur-Orge (France).  
**SOME ASPECTS OF FLIGHT MEASUREMENTS AND CALIBRATIONS**  
J. F. Renaudie / In AGARD Flight Test Tech. Feb. 1972 12 p (See N72-20976 12-02)  
Avail: NTIS

The calibration, application, and limitations of instruments used for flight tests are discussed. The various aspects of flight testing which are presented are: (1) airspeed measurement, effects of atmospheric pressure at supersonic speed, (3) errors introduced by pitot-static boom location, (4) atmospheric calibration curves for high and low altitude, and (5) correlation of flight test and wind tunnel test data. The main source of errors in various aspects of flight testing are examined and corrective actions are recommended. Author

**N72-20885#** Air Force Flight Test Center, Edwards AFB, Calif. Performance and Flying Qualities Branch.  
**CRUISE PERFORMANCE TESTING OF ADVANCED AIRCRAFT**  
Richard R. Hildebrand / In AGARD Flight Test Tech. Feb. 1972 12 p ref (See N72-20976 12-02)  
Avail: NTIS

The expanded performance capabilities of modern, high performance aircraft have necessitated the development of flight test techniques and methods of data analysis and presentation which differ from those traditionally employed. The variable-geometry wing of the F-111 presented the flight test engineer with the problem of defining and presenting cruise performance for a potentially infinite number of differently configured airplanes. The introduction of aircraft specifically designed to cruise at high supersonic Mach numbers presented still other problems. Some of the problems encountered and solutions developed during flight testing of such aircraft as the F-111, B-58, and SR-71 are presented. Author

**N72-20886#** National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif.  
**LIFTING BODY FLIGHT-TEST TECHNIQUES**  
Garrison P. Layton, Jr. and Milton O. Thompson / In AGARD Flight Test Tech. Feb. 1972 9 p refs (See N72-20976 12-02)  
(NASA-TM-X-68308) Avail: NTIS CSCL 01B

Specific techniques and procedures for conducting flight tests of lifting body type aircraft are presented. The characteristics of the aircraft in transonic and supersonic flight regions were investigated. The data collection and analysis techniques with which the flight results were analyzed are outlined. Included are analog and digital matching techniques for



derivative extractions and a method for extracting lift and drag data. Problems encountered in the flight test program and methods for solving these problems are discussed. Author

**N72-20987#** Aerospace Engineering Test Establishment, Ottawa (Ontario).

**ACCEPTANCE FLIGHT TESTING OF MILITARY AIRCRAFT**  
E. J. Sennett and L. V. P. Galvin (USABPA, Ft. Worth, Tex.) *In* AGARD Flight Test Tech. Feb. 1972 4 p (See N72-20976 12-02)

Avail. NTIS

The acceptance flight test procedures developed and used by the Canadian Armed Forces are presented. The techniques are applied to all aircraft on initial delivery and following repair and overhaul to ensure proper operation of all aircraft systems by logical functional checks and quality control procedures. Crew requirements for performing the flight tests are outlined. Author

**N72-20988#** Naval Air Test Center, Patuxent River, Md. Carrier Suitability Branch.

**CARRIER SUITABILITY TESTS**

Roger M. Decker *In* AGARD Flight Test Tech. Feb. 1972 16 p (See N72-20976 12-02)

Avail. NTIS

A resume of tests performed to determine the suitability of an airplane for launching and recovery operations in aircraft carriers is presented. Carrier suitability testing involves for the most part the blending of the pilot/airframe combination with special equipment in this unique environment. Flight test methods utilized to define the performance and handling qualities of an airplane are not unique and are given only cursory treatment. Criteria which should be considered in the design of carrier-based aircraft so as to most advantageously match an airplane to the carrier environment are presented. Author

**N72-20989#** Air Force Flight Test Center, Edwards AFB, Calif.

**FLIGHT TESTING FOR TURNING PERFORMANCE**

Roger C. Crane *In* AGARD Flight Test Tech. Feb. 1972 10 p refs (See N72-20976 12-02)

Avail. NTIS

The types of performance test maneuvers used for evaluating the turning capability of military aircraft are presented. The application of the turning performance techniques to F-104, F-4, F-4E, and F-111D aircraft is discussed. The techniques for determining the turning limitations imposed by airframe lift and engine thrust production are described. Author

**N72-20990#** Royal Aircraft Establishment, Bedford (England).

**STABILITY AND CONTROL TESTS ON A SLENDER WING RESEARCH AIRCRAFT**

P. L. Bisgood *In* AGARD Flight Test Tech. Feb. 1972 13 p refs (See N72-20976 12-02)

Avail. NTIS

A variety of flight test techniques has been used to measure the stability and control characteristics of a slender-wing research aircraft as part of a program aimed at comparing wind tunnel and flight measurements. Derivatives obtained by alternative methods in flight usually showed satisfactory agreement. Conventional methods of derivative extraction proved adequate in areas where minor non-linearities occurred in the aerodynamic coefficients. Where more pronounced non-linearities exist, as in the longitudinal case, the results indicate that conventional techniques may not be entirely adequate. Author

**N72-20991#** Fiat S.p.A., Turin (Italy). Flight Mechanics Engineering.

**AN INTEGRAL METHOD FOR EXTRACTION OF AERODYNAMIC COEFFICIENTS FROM FLIGHT-TEST DATA**

G. P. Foroni *In* AGARD Flight Test Tech. Feb. 1972 6 p refs (See N72-20976 12-02)

Avail. NTIS

The application of the equations of motion methods, which in the practice are the most advantageous, shows some difficulties and failures in the effectiveness and generality of employment. In order to overcome these deficiencies, after a short review of the principal methods, an integral procedure has been developed, which is a synthesis of the Fourier Transform and Shinnott's methods; and it has also all the advantages of them. The method accuracy has then been improved by applying an optimization process of the mathematical model, based on the O.H. Gerlach correlation coefficients. Author

**N72-20992#** Technische Hogeschool, Delft (Netherlands).

**THE DETERMINATION OF STABILITY DERIVATIVES AND PERFORMANCE CHARACTERISTICS FROM DYNAMIC MANOEUVRES**

O. H. Gerlach *In* AGARD Flight Test Tech. Feb. 1972 23 p refs (See N72-20976 12-02)

Avail. NTIS

Three frequency ranges of interest to the flight dynamicist are distinguished: (1) the low-frequency or phugoid and spiral mode frequency range, (2) the intermediate or short-period and Dutch roll frequency range, and (3) the high-frequency or elastic modes frequency range. Until today most flight tests for the determination of stability derivatives have been directed towards the intermediate frequency range. Since for various reasons the frequency ranges show an increasing trend to overlap for several classes of modern aircraft, flight test techniques suitable for more than one frequency range may well receive more attention. Flight tests to determine derivatives in the combined low and intermediate frequencies are described. The importance of accurate measurements and of an adequate frequency content of the input signal in the flight tests is stressed. The rationale behind the choice of the shape of the input signal used in the flight tests is given. The application of the derivatives, not only for stability and control purposes, but also for the determination of performance characteristics, is discussed. Author

**N72-20993#** Centre d'Essais en Vol, Istres (France).

**SCHOOL OF NAVIGATION PERSONNEL FOR TESTS AND RECEPTION (L'ECOLE DU PERSONNEL NAVIGANT D'ESSAIS ET DE RECEPTION)**

Francois Cousson *In* AGARD Flight Test Tech. Feb. 1972 11 p *In* FRENCH (See N72-20976 12-02)

Avail. NTIS

The formation of a French school, necessary to train navigation specialists in flying techniques, is discussed. The school is open to foreign personnel on an equal basis. The particular characteristics necessary for the administration of flying instruction on the ground and in the air are included.

Transl. by E.H.W.

**N72-20994#** Air Force Flight Test Center, Edwards AFB, Calif.

**US AIR FORCE AEROSPACE RESEARCH PILOT SCHOOL**

Spence M. Armstrong *In* AGARD Flight Test Tech. Feb. 1972 8 p (See N72-20976 12-02)

Avail. NTIS

The organization and operation of the U.S. Air Force Test Pilot School at Edwards AFB, California is discussed. Subjects presented are: (1) the mission of the school, (2) the staff, (3) student qualification, (4) the curriculum, (5) the flying program, and (6) methods of instruction. Additional discussion is presented on the assignment of students after graduation and future plans for the school. Author

**N72-20995#** Royal Air Force, Farnborough (England).

**TRAINING PILOTS TO ASSESS FLIGHT SYSTEMS AT THE EMPIRE TEST PILOTS' SCHOOL**

A. A. Clark *In* AGARD Flight Test Tech. Feb. 1972 6 p (See N72-20976 12-02)

Avail. NTIS

The syllabus and training curriculum for the Empire Test Pilot School in England is presented. One aspect of the training, which is identified as assessment of flight systems, is emphasized.

Features of the system are: (1) a ground training program in systems and control engineering, (2) an autopilot investigation exercise, (3) two simulator exercises, (4) an inflight autopilot assessment, and (5) a flight path control system assessment.

Author

**N72-20886/** Naval Air Test Center, Patuxent River, Md.  
**US NAVAL TEST PILOT TRAINING**  
Robert V. Sallada / In AGARD Flight Test Tech. Feb. 1972  
16 p (See N72-20876 12-02)  
Avail: NTIS

The philosophy of instruction, as it pertains to the education of U.S. Naval engineering test pilots and engineers is discussed. Selection processes, the composition of classes, and detailed scope of both academic and flight (fixed and rotary wing) syllabi are included. The fleet of aircraft is described, along with the use of each particular airplane-type in the curriculum. Also provided is a recent staff reorganization and major plans for the future which will substantially improve the student education and Navy test pilot utilization.

Author

**N72-27016/** Advisory Group for Aerospace Research and Development, Paris (France).  
**AIRFRAME/ENGINE INTEGRATION**  
A. Ferri May 1972 197 p refs  
(AGARD-LS-53) Avail: NTIS HC \$12.00

Analytical and experimental methods for investigating interference problems in airplane design optimization are reported. Considered are inlet-airplane interference, nozzle geometry and exhaust jet-airplane interference dynamics of engine and airplane characteristics. For individual titles, see N72-27017 through N72-27023.

**N72-27017** New York Univ., N.Y.  
**ENGINE AIRPLANE INTERFERENCE DEFINITION OF THE PROBLEM AND RELATED BASIC FLUID DYNAMIC PHENOMENA**

Antonio Ferri / In AGARD Airframe/Engine Integration May 1972 12 p refs (For availability see N72-27016 18-02)

This lack of simulation of the engine flow introduces substantial differences between the aerodynamics of the actual airplane and of the model tested. Characteristics related to the interference between an airplane and the engine, and their effects on the calculated performance of the airplane are integrated into analog and digital simulation, where the wind tunnel or test stand provides analog data, to improve the results.

G.G.

**N72-27018** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio  
**INLET/AIRPLANE INTERFERENCE AND INTEGRATION**  
Philip P. Antonatos, Lewis E. Surber, and Donald J. Stava / In AGARD Airframe/Engine Integration May 1972 64 p refs (For availability see N72-27016 18-02)

The basic technological problems and potential solutions relating to the development of inlet and airframe design criteria are discussed. Results of analytical and experimental work emphasize details of closely coupled inlet airframe concepts. Inlet flow fields generated by basic forebody and forebody/wing combinations are reviewed together with an analysis of the effects of variations in fuselage shape, forebody camber, wing geometry, and inlet position. Problems associated with boundary layer development and vortex ingestion are discussed in terms of their effect on inlet design. Attitude effects such as angle of attack and angle of yaw are reviewed. The losses due to spillage, bleed and bypass flows are analyzed as they affect vehicle performance.

Criteria are reviewed to minimize such loss for the development of optimal inlet/airframe performance. Specific problems relating to the subsonic-transonic flight regime and the supersonic regime are included.

Author

**N72-27019** Aircraft Research Association, Ltd., Bedford (England)

**EXPERIMENTAL DETERMINATION OF INLET CHARACTERISTICS AND INLET AND AIRFRAME INTERFERENCE**  
E. C. Carter / In AGARD Airframe/Engine Integration May 1972 24 p refs (For availability see N72-27016 18-02)

The following experimental methods are considered: Measurement of the interference of the inlet on the airframe, measurement of the interference of the airframe on the inlet, and measurement of the performance of the inlet/airframe combination as a whole. The use of complete aerodynamic force models and partial models is discussed including the drag use of full and half model tunnel techniques. Particular attention is given to drag. Shortcomings of the present techniques are pointed out and alternative proposals are made where possible.

Author

**N72-27020** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)

**NOZZLE/AIRFRAME INTERFERENCE AND INTEGRATION**  
Felix Aulehla and Kurt Loter / In AGARD Airframe/Engine Integration May 1972 25 p refs (For availability see N72-27016 18-02)

The main parameters involved in the interference between internal and external flow are discussed. Also considered is how these parameters in principle affect afterbody drag. Then the definition of rear end drag is given in the conventional way and also in a more relative manner approaching the physical optimum. For configurations with single and twin engines installed in the rear end of the fuselage wind tunnel test results for various nozzle concepts are presented and discussed. The geometric variations in these tests comprise boattail angle, size and location of the base, nozzle interfairings and engine spacing. Proper consideration of these geometric parameters in nozzle/airframe integration, reduces additional afterbody drag drastically in the transonic flight regime.

Author

**N72-27021** National Aerospace Lab., Amsterdam (Netherlands)  
**EXPERIMENTAL DETERMINATION OF NOZZLE CHARACTERISTICS AND NOZZLE AIRFRAME INTERFERENCE**

F. Jaarsma / In AGARD Airframe/Engine Integration May 1972 45 p refs (For availability see N72-27016 18-02)

An outline is given under which circumstances certain jet flow and nozzle parameters should be simulated in the wind tunnel for both installed thrust and drag determination. The circumstances relate to the flight regimes, nozzle types and engine installation configurations. Next the technical requirements for the wind tunnel and the model are given and the difficulties in fulfilling these requirements are discussed. The techniques and schemes as used by the various groups in the AGARD countries are reviewed. Special attention is given to miniature turbo engine simulators.

Author

**N72-27022** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio

**DYNAMIC CHARACTERISTICS OF ENGINE INLETS**  
Demetrius Zonars / In AGARD Airframe/Engine Integration May 1972 16 p refs (For availability see N72-27016 18-02)

Inlet random pressure fluctuations and their effects on reducing the stall margin of turbojet engines are discussed. A review is accomplished of the TF 30/F-111 compatibility study over the past several years. The practicality of utilizing steady state and instantaneous distortion factors to determine inlet-engine compatibility is assessed and recent advances in inlet research configurations with associated steady state and dynamic distortions are presented. Finally, a complete random data acquisition, editing, and processing method is developed for accomplishing data analysis as an inlet diagnostic tool.

Author

**N72-27023** Naval Postgraduate School, Monterey, Calif.  
**ENGINE INTEGRATION AND THRUST/DRAG DEFINITION**  
 Allen E. Fuhs *In* AGARD Airframe/Engine Integration May 1972 21 p refs (For availability see N72-27016 18-02)

Various definitions relating to thrust and drag are considered. Since thrust minus drag is of primary interest, the background on drag determination is discussed. This is followed by testing techniques for full scale propulsion systems. Sources of installation losses are of considerable interest. Several different methods have evolved to account for various terms in a drag/thrust determination. Bookkeeping of forces and momentum flux is described. Any aircraft development is controlled by schedules and fixed resources. Influence of these constraints on engine-airframe integration is discussed. Some special integration problems, e.g., engine bleed air, are considered. Author

**N72-32017#** Advisory Group for Aerospace Research and Development, Paris (France).  
**HANDLING QUALITIES CRITERIA**  
 Jun. 1972 293 p refs. Proc. of the AGARD Flight Mech. Panel Specialists Meeting, Ottawa, 28 Sep.-1 Oct. 1971 (AGARD-CP-106) Avail. NTIS HC \$17.00

The proceedings of a conference on the handling qualities of aircraft are presented. Subjects discussed are: (1) flying qualities requirements and criteria for conventional and V/STOL aircraft (2) commercial flying quality standards and flight test validation, (3) establishment of flying qualities by analysis of current aircraft, simulation and analysis, and pilot opinion ratings, (4) special problems and interfaces in aircraft control, and (5) man machine relationships and research and development projects for improvement. For individual titles, see N72-32018 through N72-32038.

**N72-32018** Service Technique Aeronautique, Paris (France).  
**COMPARISON OF FRENCH AND UNITED STATES FLYING QUALITIES REQUIREMENTS**  
 Jean-Claude Wanner and John W. Carlson (ASD) *In* AGARD Handling Qualities Criteria Jun. 1972 15 p (For availability see N72-32017 23-02)

The flying qualities requirements for French and United States aircraft are compared. It was determined that the two sets of criteria are basically the same in intent and goals. The complications in applying these criteria to modern, high performance aircraft are discussed. Concepts in level of handling qualities, application of flight envelope restrictions, and effects of system failures on flying properties are examined. Author

**N72-32019** Aeroplane and Armament Experimental Establishment, Boscombe Down (England).  
**THE NATURE AND USE OF THE RULES FOR JUDGING THE ACCEPTABILITY OF THE FLYING QUALITIES OF FIXED WING AIRCRAFT**

S. J. Andrews *In* AGARD Handling Qualities Criteria Jun. 1972 10 p ref (For availability see N72-32017 23-02)

The flying qualities requirements for the United Kingdom and the United States are compared. The documents involved in establishing the criteria are examined. The general content of the documents in relation to the requirements of the flight tester in assessing the acceptability of fighter aircraft, strike aircraft, and trainer aircraft is discussed. Comment is submitted on the flying qualities requirements for V/STOL aircraft. It is suggested that the requirements documents are of limited use to the flight tester because they are either out of date or inapplicable to new aircraft with special role demands or novel design features. It is recommended that, in addition to updating existing requirements, more attention should be given to the direct and immediate application of data from known and tried service aircraft. Author

**N72-32020** Federal Aviation Administration, Washington, D.C.  
**FAA FLYING QUALITIES REQUIREMENTS**  
 Richard Stiff and Robert F. LeSue *In* AGARD Handling Qualities Criteria Jun. 1972 6 p (For availability see N72-32017 23-02)

The need for flexibility and change of Federal Aviation Regulations to accommodate new designs and innovations to flying vehicles is an ever-increasing and complex situation. The current philosophies and projected difficult areas associated with airplane handling qualities are discussed. The subject is not intended to be covered as to the specific conditions or types of airplanes but, rather, to cover the qualitative evaluation needs for determining compliance with the existing airworthiness rules. Recognizing that aircraft development and capability is an ever-improving science, the relationship of Federal rulemaking procedures to the application of judgment in the requirements to produce timely and adequate determinations of compliance is discussed with consideration of complex control systems and rapidly-expanding flight envelopes. Author

**N72-32021\*** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.  
**REVISIONS TO V/STOL HANDLING QUALITIES CRITERIA OF AGARD REPORT 408**

Seth B. Anderson and Laurel G. Schroers (Army Air Mobility Res. and Develop. Lab., Moffett Field, Calif.) *In* AGARD Handling Qualities Criteria Jun. 1972 8 p refs (For availability see N72-32017 23-02)

A brief review of selected handling qualities criteria for V/STOL aircraft shows that although a clearer understanding of the requirements for controversial areas such as roll control power, vertical flight path control, and transition is in hand, considerably more research is needed to refine these criteria for operational IFR activity. Because many items interact to influence the pilots' overall impression of the aircraft's behaviour, additional work of a systematic nature must be done to clarify this aspect. A better definition of a gust model which includes discrete gust effects is needed to firm up criteria for both hover and STOL operation. Author

**N72-32022** Cornell Aeronautical Lab., Inc., Buffalo, NY  
**US MILITARY V/STOL HANDLING QUALITY REQUIREMENTS**

Charles R. Chalk and Charles B. Westbrook (AFFDL) *In* AGARD Handling Qualities Criteria Jun. 1972 13 p refs (For availability see N72-32017 23-02)

The V/STOL aircraft handling qualities criteria specification is discussed. The evolution of the specification is traced over the five year period of its development. Problem areas requiring additional work are defined as well as research efforts to address some of the problem areas. Author

**N72-32023** Canadair, Ltd., Montreal (Quebec).  
**APPLICATION OF V/STOL HANDLING QUALITIES CRITERIA TO THE CL-84 AIRCRAFT**

O. E. Michaelsen *In* AGARD Handling Qualities Criteria Jun. 1972 26 p refs (For availability see N72-32017 23-02)

The design concepts and flight characteristics of the Canadair CL-84 tilt wing V/STOL aircraft as related to handling qualities are reviewed. The achieved characteristics are compared with the revised AGARD V/STOL Handling Qualities Criteria. It is shown that the CL-84 characteristics are in general accord with the Criteria. While a few of the Criteria values appear inappropriate for the CL-84, it is concluded that the handling qualities of the aircraft would be improved if the aircraft met most of the Criteria in the areas where it presently falls short. Author

**N72-32024** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

**V/STOL HANDLING QUALITIES CRITERIA COMPARED WITH FLIGHT TEST RESULTS OF THE V/STOL SUPERSONIC FIGHTER VJ 101C AND THE V/STOL TRANSPORT AIRCRAFT DO 31E**

G. K. Kiesel and Horst Wuennenberg (Dornier AG, Friedrichshafen) *In AGARD Handling Qualities Criteria* Jun. 1971 16 p refs (For availability see N72-32017 23-02)

The V/STOL aircraft handling qualities criteria are compared with the flight test results for the VJ 101C V/STOL supersonic fighter aircraft and the DO 31E V/STOL transport aircraft. The main features of the takeoff and landing procedures are presented. The handling qualities of the two aircraft in hover and transition flights are compared with accepted recommendations. The influence of the stabilization system and its characteristics on the control power is examined. The effects of the jet induced downwash and of the hot gas recirculation are shown. Author

**N72-32025** Air Force Flight Test Center, Edwards AFB, Calif. Performance and Flying Qualities Branch

**CRITERIA TRENDS OBTAINED FROM ANALYSIS OF CURRENT AIRCRAFT**

Charles F. Adolph *In AGARD Handling Qualities Criteria* Jun. 1972 9 p refs (For availability see N72-32017 23-02)

The need for developing additional criteria specifically for evaluation purposes is discussed. Also included are discussions of several other topics in the flying qualities area which have been recurrent items of interest in evaluations of high performance aircraft. Included are comments on high angle of attack criteria, an overview of the results from evaluations of aircraft equipped with control augmentation systems, and a summary of experiences in applying flying quality criteria. Author

**N72-32026** Northrop Corp., Hawthorne, Calif. **SIMULATION AND ANALYSIS IN ESTABLISHING FLYING QUALITIES CRITERIA**

J. T. Gallagher *In AGARD Handling Qualities Criteria* Jun. 1972 26 p refs (For availability see N72-32017 23-02)

The application of simulation and analysis in establishing the flying qualities criteria for piloted aircraft is discussed. Two areas are identified where better criteria are needed in the specification: (1) the effects of turbulence and (2) the impact of control system dynamics on flying qualities. A discussion is presented on a program which employs ground based simulation and pilot analysis in an attempt to better define the impact of turbulence on flying qualities. Methods for overcoming existing shortcomings in the procedure are evaluated. Author

**N72-32027** Boeing Co., Seattle, Wash. **HANDLING QUALITIES CRITERIA FOR SUPERSONIC TRANSPORT**

W. T. Kahrer *In AGARD Handling Qualities Criteria* Jun. 1972 6 p (For availability see N72-32017 23-02)

The content and tone of a criteria specification for commercial transports are presented. A criteria must insure safe handling qualities for all regimes of flight operation. In addition to the normal flight operations, operation to the extremes of the flight envelope, and operation in severe turbulence must be specified. Also to be considered are flight operations with systems failures. A criteria specification must also consider the critical combinations of these items that have a reasonable probability of occurrence. For example, the airplane must be able to operate safely in turbulence of some specified level following flight controls systems failures. Author

**N72-32028** Cornell Aeronautical Lab., Inc., Buffalo, N.Y. Flight Research Dept.

**THE ROLE OF PILOT RATING IN THE DEVELOPMENT OF HANDLING CRITERIA**

Robert P. Harper, Jr. *In AGARD Handling Qualities Criteria* Jun. 1972 7 p refs (For availability see N72-32017 23-02)

The application of pilot rating in determining the performance and handling criteria of aircraft is discussed. The role of pilot rating as a means of defining the quality of handling in those control situations where a direct measurement cannot be made is described. The development and application of a pilot rating scale for aircraft evaluation are examined. Author

**N72-32029** London Univ. (England). Dept. of Aeronautical Engineering

**CRITERIA FOR STALL AND POST STALL GYRATIONS**

G. J. Hancock *In AGARD Handling Qualities Criteria* Jun. 1972 10 p (For availability see N72-32017 23-02)

Problems associated with the handling characteristics during approaches to and excursions beyond the operational limits of commercial aircraft are discussed. The evolution of airworthiness requirements for the stall and post stall operation of aircraft is described. The effects of minimum speed in steady level flight, the specification of the factors of safety, and the demonstration of satisfactory dynamic behavior beyond the operational limits on the design of the aircraft are analyzed. Author

**N72-32030** Royal Aircraft Establishment, Bedford (England). **TURBULENCE MODELS FOR THE ASSESSMENT OF HANDLING QUALITIES DURING TAKE OFF AND LANDING**

J. G. Jones *In AGARD Handling Qualities Criteria* Jun. 1972 15 p refs (For availability see N72-32017 23-02)

Properties of atmospheric turbulence at low altitude are reviewed, with particular reference to those aspects relevant to an aircraft on a landing approach or during take off. Measurements of power spectra are described and related to a simplified theoretical model. Looking beyond the power spectrum, an important property of turbulence is its intermittency, related to a tendency for aircraft response to show large peaks separated by regions of relative inactivity. Pilots appear to be particularly sensitive to this intermittent structure, and their subjective comments can be related to measured turbulence characteristics. It is shown how a discrete gust model for turbulence may be employed to predict the magnitude of large response peaks. As an example, the response to gusts of an aircraft constrained to fly at constant altitude is discussed, with particular reference to the effects of aircraft speed. Author

**N72-32031** North American Rockwell Corp., Los Angeles, Calif. **FLYING QUALITIES INTERACTION WITH ELASTIC AIRFRAMES**

John H. Wykes *In AGARD Handling Qualities Criteria* Jun. 1972 13 p refs (For availability see N72-32017 23-02)

The trends in modern aircraft structural design and aerodynamics are such that vehicle flexibility increasingly impacts on vehicle flying (handling) qualities and the design processes necessary to provide satisfactory vehicles. In recent years, the flexibility effects on ride quality have impacted on handling qualities and, perhaps, should be added to handling qualities requirements or criteria. A presentation is given of some of the approaches currently being considered to reduce this interaction. These include such techniques as active seat isolation and active structural mode control. It is concluded that any ride quality solution method that includes inducing motion between the pilot and his controls and displays should be excluded by handling qualities criteria. The structural flexibility and flight controls interface is briefly examined, and a typical pilot-induced structural

excitation is discussed. It is suggested that a pilot prefilter, a modern stability augmentation system, and a structural mode control system designed to meet ride quality criteria can solve the problem without additional criteria. The handling qualities flexibility interaction and the vehicle design cycle are discussed.

Author

**N72-32032** Societe Nationale Industrielle Aerospatiale, Toulouse (France).

**INFLUENCE OF THE DESIGN AND FUNCTIONING CHARACTERISTICS OF THE FLYING CONTROL SYSTEM OF A TRANSPORT AIRCRAFT ON ITS FLIGHT QUALITIES**  
R. Deque. In AGARD Handling Qualities Criteria Jun. 1972 12 p (For availability see N72-32017 23-02)

The problems encountered in the course of flying quality studies for both a supersonic and a subsonic transport aircraft are described. A study is made of the influence of the static and dynamic characteristics of controls between cockpit controls and surfaces without automatic compensators. The specific problems raised by automatic compensation are examined. A study is made of how flying qualities are affected by flying control failures and by the safety and reliability objectives which must as a consequence be achieved.

Author

**N72-32033** National Aeronautical Establishment, Ottawa (Ontario).

**PARAMETERS AFFECTING LATERAL DIRECTIONAL HANDLING QUALITIES AT LOW SPEEDS**  
K-H. Doetsch, Jr. In AGARD Handling Qualities Criteria Jun. 1972 13 p ref (For availability see N72-32017 23-02)

A study is undertaken of the factors affecting the lateral-directional handling qualities of aircraft in typical VMC STOL flight as certain model parameters are varied. It is found that for the low flight-speed and the low dutch roll frequencies investigated, the side force equation takes on added significance in establishing the oscillatory mode through the vector contribution of the weight component acting along the y-axis. When this contribution is large, secondary effects on handling qualities can arise if the relationship between the yaw rate and sideslip vectors in the oscillatory mode is established solely by varying the derivatives of the moment equations because, under these circumstances, unusual groups of derivatives may be necessary to satisfy the imposed constraints. Similar deviations from normal values for the moment derivatives may be required to force the zeros from the poles in the bank angle to aileron-control transfer function while simultaneously maintaining the correct vector relationships in the oscillatory mode.

Author

**N72-32034** Technische Hogeschool, Delft (Netherlands).

**PILOT VEHICLE ANALYSIS**  
R. J. A. W. Hoeman. In AGARD Handling Qualities Criteria Jun. 1972 26 p refs (For availability see N72-32017 23-02)

An experiment is described in which measurements were performed on human operators in single axis tracking tasks. The controlled element used was a simulated transport aircraft, the angle of pitch was controlled by the human operator. The forcing function was a gust signal acting on the simulated aircraft. The aircraft was simulated at three cents of gravity positions at which it was stable, neutral and unstable respectively. During the test runs the human operators had to perform simultaneously an auditory additional task. On the basis of the results obtained from this experiment a new sampled data pilot model is discussed.

Author

**N72-32035** Forschungsinstitut fuer Anthropotechnik, Meckenheim (West Germany).

**PILOT WORKLOAD**  
R. K. Bernotat and Jean-Claude Wanner (Service Tech. Aeronautique, Paris). In AGARD Handling Qualities Criteria Jun. 1972 9 p refs (For availability see N72-32017 23-02)

Schematic diagrams and analyses of the functions of the human operator in the guidance and control loops are presented. Three hierarchical control loops are considered. Flow charts are established to define the stimuli received by the pilot, the data

treatment by the brain, and the subsequent physical actions. The application of the analyses to establishing the pilot workload encountered for various portions of the flight is described.

Author

**N72-32036** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.

**THEORETICAL PILOT RATING PREDICTIONS**  
Ronald O. Anderson. In AGARD Handling Qualities Criteria Jun. 1972 14 p refs (For availability see N72-32017 23-02)

Methods for specifying flying qualities of aircraft are discussed. Methods for correcting deficiencies in the present system are recommended. The recommendations range from the expansion of the classical approach to new dimensions to approaches that rely on theoretical predictions of pilot ratings. It is shown that the prediction of pilot ratings is a valid approach which is accurate within the range of pilot variability.

Author

**N72-32037** Naval Air Systems Command, Washington, D.C.

**RECENT US NAVY FLYING QUALITIES RESEARCH**  
Raymond F. Siewert. In AGARD Handling Qualities Criteria Jun. 1972 12 p refs (For availability see N72-32017 23-02)

The results of U.S. Navy sponsored flying qualities research conducted over the past five years are presented. Inflight variable stability airplane investigations were conducted in simulated carrier approaches to determine the effect of the principle flying qualities parameters on approach performance. Limits have been established on the values of the major longitudinal and lateral-directional parameters, to insure good carrier approach characteristics. In addition to the carrier approach studies, moving base simulator investigations were conducted to further develop criteria, and extend the aircraft maneuvering potential at high angles-of-attack. The inclusion of maneuvering force gradient and/or stick sensitivity has been determined as a requirement for a meaningful criterion.

Author

**N72-32038\*** National Aeronautics and Space Administration, Washington, D.C.

**RECENT NASA HANDLING QUALITIES RESEARCH**  
Richard J. Wasicko. In AGARD Handling Qualities Criteria Jun. 1972 26 p refs (For availability see N72-32017 23-02)

A comprehensive review of NASA research results documented since the mid-1960s and some recently completed programs on aircraft handling qualities are presented. In addition to handling qualities research pertaining to vehicle stability and control characteristics, investigations related to specialized piloting tasks, cockpit displays, and environmental factors are summarized. The background leading to NASA's handling qualities research activities is discussed, and programs that have received major emphasis are indicated. For general aviation aircraft, the survey includes investigations aimed at improving handling qualities by incorporating increasingly sophisticated stability augmentation and display systems, simplifying the approach and landing task for relatively inexperienced pilots, and establishing the basic effects of turbulence. Research on the specialized piloting problem of steeper instrument approaches for noise abatement and investigations with a representative first generation aircraft are reviewed in the section on subsonic jet transports. Supersonic cruise aircraft programs include a variety of simulation studies related to supersonic transport designs and flight tests with the XB-70 aircraft. Investigations of high angle of attack loss of control problems and a flight study of direct lift control utilization for formation flying and aerial refueling are discussed in the review of tactical military aircraft research.

Author

**N73-11020#** Advisory Group for Aerospace Research and Development, Paris (France).

**INTERACTION OF HANDLING QUALITIES, STABILITY, CONTROL AND LOAD ALLEVIATION DEVICES ON STRUCTURAL LOADS** Summary Report

Clifford F. Newberry (Boeing Co., Wichita, Kan.) Jul 1972 17 p refs

(AGARD-R-593) Avail. NTIS HC \$3 00

A questionnaire was forwarded to working group members, soliciting answers from their respective countries on techniques used in considering the various interactions. The questionnaire discusses possible effects of load alleviation devices from both static and fatigue loads. Interactions between stability, control, and structural loads when structural modes coalesce with rigid body short period modes are also addressed. The replies received are summarized. The replies generally agree, although differences between manufacturers of fighter and transport aircraft are evident. Author

N73-13018# Advisory Group for Aerospace Research and Development, Paris (France)  
**AGARD FLIGHT MECHANICS PANEL SYMPOSIUM ON STABILITY AND CONTROL** Technical Evaluation Report  
 William T. Hamilton (Boeing Co., Seattle) Oct. 1972 10 p  
 refs. Conf. held at Brunswick, 10-13 Apr. 1972

(AGARD-AR-48) Avail. NTIS HC \$3 00

With the passing of time and better understanding of the aerodynamic and structural characteristics of aircraft configurations the opportunities to improve aircraft performance, reliability, or cost through the use of more sophisticated control systems was recognized. These advanced control systems involved additional disciplines such as complicated mechanisms, hydraulics, electronics, and new visual systems. Author

N73-13019# Advisory Group for Aerospace Research and Development, Paris (France)  
**A RELATION BETWEEN MEASURED CENTER OF GRAVITY VERTICAL ACCELERATIONS AND THE LOADS AT THE T-TAIL OF A MILITARY AIRPLANE**

O. Buxbaum (Lab fuer Betriebsfestigkeit, Daimler-Benz AG, Eberstadt, West Germany) Sep 1972 20 p refs  
 (AGARD-597) Avail. NTIS HC \$3 00

A method for the establishment of a statistical basis for the relations between center of gravity vertical accelerations and structural loads on a tailplane is described. The development and application of a fatigue meter for this purpose are discussed. Bending moments and load factors are plotted as graphs to show reliability of test procedures. Author

N73-14998# Advisory Group for Aerospace Research and Development, Paris (France)

#### FLUID DYNAMICS OF AIRCRAFT STALLING

Nov 1972 342 p refs. Partly in ENGLISH and partly in FRENCH. Presented at Fluid Dyn. Panel Specialists Meeting, Lisbon, 25-28 Apr 1972

(AGARD-CP-102) Avail. NTIS HC \$19 25

The proceedings of a conference on the fluid dynamics of aircraft stalling are presented. The subjects discussed are: (1) two dimensional laminar separation bubbles, (2) turbulent boundary layer flows, (3) aerodynamics of high lift airfoil systems, (4) low speed stalling of wings with high lift devices, (5) stall characteristics of various military aircraft, and (6) airflow separation and buffet onset during fighter aircraft maneuvers. For individual titles, see N73-14999 through N73-15020

N73-14999 Queen Mary Coll., London (England) Dept. of Aeronautical Engineering  
**ROLE OF FLUID DYNAMICS IN AIRCRAFT STALL AND POSTSTALL GYRATIONS**

G. J. Hancock In AGARD Fluid Dyn. of Aircraft Stalling, Nov 1972 16 p refs (For availability see N73-14998 06-02)

The airworthiness requirements for stall and post stall behavior of an aircraft are reviewed. The definition of stall as the limiting condition for normal flight operations is established. The distinct dynamic and aerodynamic contributions to a stall maneuver and post stall gyration are described. The pilot's influence is assessed and some implications on airframe design are outlined. The effects of flow separation on wings, the control of flow separation, and the role of model experiments are reported. Author

N73-15000 Technische Hogeschool, Delft (Netherlands), Dept. of Aeronautical Engineering

#### SOME RESEARCH ON TWO DIMENSIONAL LAMINAR SEPARATION BUBBLES

E. Dobbings, J. L. Van Ingen, and J. W. Kooi In AGARD Fluid Dyn. of Aircraft Stalling, Nov. 1972 8 p refs (For availability see N73-14998 06-02)

Empirical information on the angle at which the separation streamline leaves the wall, in wall flow, was obtained. The laminar part of separation bubbles in two dimensional incompressible flow was calculated for the following conditions: (1) plane stagnation point boundary layer flow, (2) flow around a cylinder 70 millimeters in diameter, (3) flow around a cylinder 400 millimeters in diameter, (4) a long cylinder, axially aligned with the wind, separation induced by a forward facing step, (5) a short flat plate with separation induced by auxiliary airfoils, (6) a short flat plate with separation induced by a forward facing step, and (7) a long flat plate with separation induced by a forward facing step. The measured angles are plotted as a function of the Reynolds number at separation. Author

N73-15001 Centre National de la Recherche Scientifique, Meudon (France)

#### THEORETICAL AND EXPERIMENTAL RESEARCH OF TAKE OFF DRAG DEFORMATION OF LOCAL SURFACE [RECHERCHES THEORIQUES ET EXPERIMENTALES SUR LES DECOLLEMENTS LIES A UNE DEFORMATION LOCALE DE SURFACE]

S. Burnet, G. B. Dreyer, P. Gougat, and B. Prunet-Foch In AGARD Fluid Dyn. of Aircraft Stalling, Nov 1972 11 p refs In FRENCH (For availability see N73-14998 06-02)

A theoretical and experimental study was made of incompressible flow during takeoff. Velocity profiles were measured in the boundary layer by hot wire anemometers, and the analysis obtained used to determine frequency distribution. Static pressure distribution on the inner surface was also determined. A plate containing a cavity was used to measure deformation on the hollow ledge. Spectral density fluctuations in velocity permits the measurement of natural instabilities in the boundary layer. The instabilities are correlated with exterior speed. Author

N73-15002 Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

#### AIRFOIL STALL PREDICTION IN INCOMPRESSIBLE FLOW

Michel Vincent DePaul In AGARD Fluid Dyn. of Aircraft Stalling, Nov 1972 15 p refs In FRENCH, ENGLISH summary (For availability see N73-14998 06-02)

A calculation method is proposed to calculate the small separation zones which are initiated near the leading edge of an airfoil at incidence. This calculation provides the details of the separation process and the maximum lift that may be obtained with a certain Reynolds number range. Author

N73-15003 Northrop Corp., Hawthorne, Calif., Aircraft Div  
**PARAMETRIC STUDIES OF SEPARATING TURBULENT BOUNDARY LAYER FLOWS**

Andrzej Wortman and W. J. Franks In AGARD Fluid Dyn. of Aircraft Stalling, Nov 1972 9 p refs (For availability see N73-14998 06-02)

A new technique for the exact solutions of laminar or turbulent two- or three-dimensional boundary layer flows has been developed. The technique differs from previous approaches in the use of functional analysis to obtain exact semi-analytical solutions in a small fraction of the computer time normally required for such computations. The main advantage of the semi-analytical aspect of the technique is that the functional forms of the relations in the governing differential equations are retained and the use of the computer is relegated to the performance of simple quadratures and fluid properties calculations. Thus, the study of the various turbulent viscosity models is a matter of programming the model into the subroutine where such calculations are performed. A wide range of eddy viscosity relations can therefore be studied in a few parametric runs. A typical three-dimensional calculation at a point on a body requires 3 seconds of IBM 360/65 computer time, so that extensive parametric studies can be performed quickly and economically. Author

**N73-15004** (technische Hochschule, Stuttgart (West Germany))  
Inst. fuer Aerodynamik und Gasdynamik

**DESIGN OF AIRFOILS WITH HIGH LIFT AT LOW AND MEDIUM SUBSONIC MACH NUMBERS**

F. X. Wortmann. In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 9 p. refs (For availability see N73-14998 06-02)

The design of airfoils with high lift at low and medium subsonic speeds is discussed. It is stated that the maximum lift of a symmetrical airfoil at low Mach numbers can be increased from 15 to 20 percent if the airfoil nose is modified and designed to yield lower velocity peaks and less pronounced laminar separation bubbles. The performance of the airfoil at various subsonic speeds and angles of attack is described. Author

**N73-15005** National Aerospace Lab., Amsterdam (Netherlands)  
**COMMENTS ON THE METHODS DEVELOPED AT NLR FOR CONDUCTING TWO DIMENSIONAL RESEARCH ON HIGH LIFT DEVICES**

O. DeVries. In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 7 p. refs (For availability see N73-14998 06-02)

Avail: NTIS

Two experimental approaches for analyzing two dimensional flow on high lift devices are described. The first method consists of pressure measurements at the mid-span section of a two dimensional wing with boundary layer control at the tunnel wall-wing junctions by blowing slots. The second approach consists of potential flow calculations by means of a singularity method with a source distribution on the contour of the airfoil. This is applied with a limited number of contour points on the airfoils. The calculations are compared with the experimental results. Author

**N73-15006** Avions Marcel Dassault, Saint-Cloud (France)  
**BLOCKAGE CORRECTIONS IN BLOWING TESTS OF EFFECTS OF TAKE OFF [CORRECTION DE BLOCAGE DANS LES ESSAIS EN SOUFFLERIE EFFETS DES DECOLLEMENTS]**

Jean-Ch. Vayssaire. In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 22 p. refs. In FRENCH. ENGLISH summary (For availability see N73-14998 06-02)

The application of blockage corrections to wind tunnel test measurements made on aircraft models is discussed. The procedure corrects the velocity to infinity upstream and restores to the wall-affected aerodynamic coefficients the values which are fairly equivalent to those obtained on a model placed in an unlimited fluid stream. The corrective blockage terms which modify the reference kinetic pressure are analyzed. The terms are affected by volume, wake, and separations. Each of them is usable in incompressible, compressible, two dimensional, and three dimensional flows on whole or half models. Author

**N73-15007** Douglas Aircraft Co., Inc., Santa Monica, Calif.  
**AERODYNAMICS IN HIGH LIFT AIRFOIL SYSTEMS**

A. M. O. Smith. In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 27 p. refs (For availability see N73-14998 06-02)

The aerodynamic processes that occur in flow past unpowered multi-element airfoils in the high lift attitude are discussed. Charts showing permissible pressure recovery for retarded flows are presented. The best possible load carrying pressure distributions are described, as well as airfoils that develop the maximum possible lift in fully attached flow. It is shown that for a given optimum type of pressure distribution a two-element airfoil can develop more lift than a single element airfoil shaped to develop the same pressure distribution. Author

**N73-15008** Royal Aircraft Establishment, Farnborough (England)  
**THE LOW SPEED STALLING OF WINGS WITH HIGH LIFT DEVICES**

D. N. Foster. In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 12 p. refs (For availability see N73-14998 06-02)

The mechanism of the stall of wing sections with high-lift devices in two dimensional flow is discussed. The similarities to the stalling mechanism for single airfoils, and the differences which arise as a result of the close proximity of the multiple lifting elements of the wing section to each other are described. The effect of sweepback is discussed for an infinite sheared

wing and for a finite aspect ratio wing with high lift devices. The effects of practical features such as part-span flaps, and flap and slat support brackets, are illustrated by reference to flow patterns measured on a swept back wing. Author

**N73-15009** General Dynamics/Fort Worth, Tex.  
**A SIMPLIFIED MATHEMATICAL MODEL FOR THE ANALYSIS OF MULTIELEMENT AIRFOILS NEAR STALL**

I. C. Bhatelay and R. G. Bradley. In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 12 p. refs (For availability see N73-14998 06-02)

Potential-flow analysis methods, based on distributed-singularity models, are adequate for the prediction of aerodynamic characteristics for 2-D multiple-airfoil systems where viscous effects are negligible. However, for analysis and design of high-lift systems where viscous effects dominate, potential-flow methods are not adequate. In order that these viscous effects may be accounted for, a method has been formulated by which a solution is obtained through analysis of an equivalent airfoil system in potential flow. The mathematical model for the equivalent system consists of a linearly varying vorticity distribution over the surface of each airfoil element and a source distribution embedded inside each airfoil element to simulate the separated wake. The boundary-layer displacement thickness is superimposed on the airfoil contour to form an equivalent airfoil surface for each element. The flow downstream of a separation point is allowed to develop as a free streamline flow with no surface boundary conditions. The mathematical model is evaluated for cases where the location of the separation point is specified from experimental data. The predicted chordwise pressure distributions are shown to correlate well with experimental data for several multiple airfoils (including leading edge slats and trailing-edge slotted flaps) for angles of attack near stall. Author

**N73-15010** Royal Aircraft Establishment, Farnborough (England)  
**THE EFFECT OF LEADING EDGE GEOMETRY ON HIGH SPEED STALLING**

G. F. Moss, A. B. Haines (Aircraft Res. Assoc.), and R. Jordan (Aircraft Res. Assoc.). In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 16 p. refs (For availability see N73-14998 06-02)

It is shown by means of an example how small modifications to the leading-edge profile of a sweptwing can result in large effects on lift performance at the stall in the higher range of subsonic speeds. The basic types of leading-edge pressure distribution for any one fixed geometry over the whole range of subsonic speed are discussed and the difficulties in designing a profile shape which gives a satisfactory compromise in wing performance across this range is emphasized. Two types of variable-geometry device at the leading edge are discussed, each of which allows some degree of optimization in the shape required for good aerodynamic performance across the range of Mach numbers. Author

**N73-15011** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Control Criteria Branch

**A PRACTICAL LOOK AT THE STALL AND HIGH LIFT OPERATION OF EXTERNALLY BLOWN FLAP STOL TRANSPORT CONFIGURATIONS**

David J. Moorehouse. In AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972. 13 p. refs (For availability see N73-14998 06-02)

Some practical design aspects of the stall of powered-lift aircraft having externally blown flaps are considered. Techniques are examined for predicting the increment in maximum lift coefficient due to power. Numerical results are presented for an existing theory based on the assumption of a leading-edge stall and the use of basic jet-flap theory. The accuracy of the theory is better than might be expected, and an empirical factor is added to produce good correlation with measured values. A completely empirical approach is shown to be effective as a simple technique to provide quick approximations to the increment in maximum lift coefficients. Author

**N73-15012** British Aircraft Corp., Warton (England). Aerodynamics Dept.  
**FLIGHT DEVELOPMENT OF THE STALLING CHARACTERISTICS OF A MILITARY TRAINER AIRCRAFT**

W. D. Horsfield and G. P. Wilson. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 9 p. (For availability see N73-14998 06-02)

The modifications to the Jet Provost Mk. 6 and the Strikemaster 167 aircraft to improve the stall warning characteristics are reported. The procedures for obtaining the desired characteristics of a clearly marked stall with adequate warning of the approach without penalty on maximum lift and without involving large aircraft modifications are described. Diagrams and illustrations of the final configurations are included. Author

**N73-18013 General Dynamics/Fort Worth, Tex.  
STALL/POST-STALL CHARACTERISTICS OF THE F-111  
AIRCRAFT**

Charles A. Anderson. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 9 p. (For availability see N73-14998 06-02)

The stall/post-stall characteristics of the F-111 aircraft are described. The characteristics have been defined on the basis of wind tunnel tests, free-flight model tests, radio controlled drop model tests, analytical analysis, and flight tests. The extent of each type of testing is discussed and a summary of the results is presented. A discussion of the regression techniques used to obtain aerodynamic derivatives in the high angle of attack simulator is included. Author

**N73-18014 Hawker Siddeley Aviation, Ltd., Kingston upon Thames (England)**

**POST-STALL AERODYNAMICS OF THE HARRIER GR1**

Cliff L. Bore. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 7 p. refs. (For availability see N73-14998 06-02)

The post-stall aerodynamics of the Harrier GR1 aircraft are discussed. The requirement to achieve high usable lift coefficients during maneuvering at subsonic speeds, without incurring a weight penalty for leading edge devices is described. The resulting characteristics of boundary layer separation after buffet onset are analyzed. The effects of arrays of fences and vortex generators are examined. Author

**N73-18015 Royal Netherlands Aircraft Factories Fokker, Amsterdam**

**AERODYNAMICS OF WING STALL OF THE FOKKER F28**

T. Schuringa. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 6 p. (For availability see N73-14998 06-02)

The aerodynamic development of the F28 wing with regard to the stall are described. First, the investigation in the wind tunnel is reported, dealing with the influence of boundary layer fences; secondly the correlation with flight tests is presented. It may be concluded that, apart from minor modifications, satisfactory agreement was found between wind tunnel and flight test results. Author

**N73-18016 Boeing Co., Seattle, Wash.  
PREDICTING THE LOW SPEED STALL CHARACTERISTIC  
OF THE BOEING 747**

John K. Wimpess. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 9 p. (For availability see N73-14998 06-02)

The pre-flight estimates for the Boeing 747, based on wind tunnel data obtained at a Reynolds Number of approximately 1 million, are presented. These test results were adjusted to full scale flight values using correlation factors developed from other Boeing transport airplanes. As an independent check, high lift data were obtained in a pressurized wind tunnel up to a Reynolds Number of 7.5 million and extrapolated to the full scale value of 40 million. Flight results show that the correlation factors were moderately successful in predicting stall speeds. Also, extrapolating the pressure tunnel data to full scale Reynolds Numbers predicted the flight value of maximum lift coefficient with reasonable accuracy. The wind tunnel data at all Reynolds Numbers predicted satisfactory handling characteristics throughout the stall that were confirmed during flight testing. Author

**N73-18017 Air Force Flight Dynamics Lab., Wright-Patterson  
AFB, Ohio, Aeromechanics Branch  
ON AIRFLOW SEPARATION AND BUFFET ONSET DURING  
FIGHTER AIRCRAFT MANEUVERING**

Peter J. Butkewicz. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 10 p. refs. (For availability see N73-14998 06-02)

An experimental flight test program was sponsored to determine the buffet characteristics of four high performance aircraft. The aircraft were flown in transonic maneuvers encountering conditions of buffeting onset through heavy buffeting. The aircraft were instrumented with accelerometers, wing root strain gages, wing static pressure taps, and one wing was tufted for flow visualization photographs. The aircraft were flown in the baseline configuration as well as with various deflections of leading and trailing edge flaps. The results of the flight test program, the effects of mechanical high lift devices on buffet, and some wind tunnel/flight test correlations are presented. Author

**N73-18018 Royal Aircraft Establishment, Bedford (England)  
THE DYNAMIC ANALYSIS OF BUFFETING AND RELATED  
PHENOMENA**

J. G. Jones. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 10 p. refs. (For availability see N73-14998 06-02)

A dynamic analysis of buffeting and related aerodynamic phenomena is presented. The closed-loop interaction between the fluid motion, involving separated flow, and the motion of the wing surface is analyzed. The problem of formulating an appropriate theoretical model for buffeting is discussed. An analogous problem concerning the choice of appropriate analytical models for oscillatory rigid-body motion, known as wing rocking, is examined. Buffeting measurements obtained from flight tests of small combat trainer aircraft are included. Author

**N73-18019\* National Aeronautics and Space Administration  
Langley Research Center, Langley Station, Va.**

**MANEUVER AND BUFFET CHARACTERISTICS OF FIGHTER  
AIRCRAFT**

Edward J. Ray (McDonnell Aircraft Co., St. Louis), Linwood W. McKinney, and Julian C. Carmichael. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 11 p. refs. (For availability see N73-14998 06-02)

The high subsonic and transonic characteristics of fighter aircraft and the factors affecting aerodynamic boundaries, such as maximum obtainable lift, buffet onset, pitchup, wing rock, and nose slice are discussed. Investigations were made using a general research configuration which encompassed a systematic matrix of wing design parameters. These results emphasized the sensitivity to section and planform geometry at the selected design point. The incorporation of variable-wing-geometry devices in the form of leading-edge slats or flaps was shown in a number of flight and wind-tunnel studies to provide controlled flow over a wide range of flight conditions and substantial improvements in maneuver capabilities. Additional studies indicated that the blending of a highly swept maneuver strake with an efficient moderately swept wing offers a promising approach for improving maneuver characteristics at high angles of attack without excessive penalties in structural weight. Author

**N73-18020 Naval Air Systems Command, Washington, D.C.  
AERODYNAMIC DESIGN AND FLIGHT TEST OF US NAVY  
AIRCRAFT AT HIGH ANGLES OF ATTACK**

W. R. Burris and J. T. Lawrence. In AGARD Fluid Dyn. of Aircraft Stalling. Nov. 1972. 10 p. refs. (For availability see N73-14998 06-02)

The aerodynamic design, engineering development, and flight testing of naval aircraft at high angles of attack are discussed. The flight regime beginning with buffet onset and proceeding up through departure from controlled flight is investigated. Post-stall gyrations and spin recovery are analyzed. The importance of the design process for low speed flight stability is emphasized. Author

**N73-18021# Advisory Group for Aerospace Research and  
Development, Paris (France)**

**STABILITY AND CONTROL**

Nov. 1972. 305 p. refs. Proceedings of the 40th Meeting of the Flight Mech. Panel of AGARD, Braunschweig West Germany, 10-13 Apr. 1972.

(AGARD-CP-119) Avail. NTIS HC \$17.25



Summaries of papers presented at conferences concerning aircraft stability, control, maneuverability and design are reported. For individual titles, see N73-16990 through N73-17013.

Author

**N73-16990** National Aerospace Lab., Amsterdam (Netherlands). **SUMMARY OF AGARD MEETING ON PROBLEMS OF THE COCKPIT ENVIRONMENT, NOVEMBER 1968 IN AMSTERDAM, NETHERLANDS**

J. J. P. Moelker. *In* AGARD Stability and Control Nov. 1972 9 p refs (For availability see N73-16989 08-02)

Problems related to the process of man-machine communication are discussed with emphasis on cockpit information-generation, display, and transfer. Techniques for the evaluation of cockpit geometry, display systems and cockpit workload are summarized together with the associated anthropometrical data and types of display systems. Author

**N73-16991** Centre d'Essais en Vol, Brétigny-sur-Orge (France). **AEROELASTIC EFFECTS FROM A FLIGHT MECHANICS STAND POINT**

J. F. Renaudie. *In* AGARD Stability and Control Nov. 1972 17 p. *In* FRENCH (For availability see N73-16989 08-02)

Methods for calculating the effects of aeroelasticity on aircraft flight are discussed. Data cover aerodynamics of flexible rotors, flight dynamics of flexible aircraft, experimental determination of flexibility for flexible aircraft, stability augmentation systems, and problems of determining influence of aerodynamic forces on flexible aircraft. Transl. by E.H.W.

**N73-16992** British Aircraft Corp., Preston (England). Military Aircraft Div. **SUMMARY PAPER ON SIMULATION MEETING, SPRING 1970 AT NASA RESEARCH CENTER**

A. G. Barnes. *In* AGARD Stability and Control Nov. 1972 5 p ref (For availability see N73-16989 08-02)

The conference on flight simulation is summarized. Topics discussed include: simulation objectives, simulator characteristics, design of experiments, simulation results, and analysis. F.O.S.

**N73-16993** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. **HANDLING QUALITIES CRITERIA AND REQUIREMENTS**

William E. Lamar and Terry L. Neighbor. *In* AGARD Stability and Control Nov. 1972 19 p refs (For availability see N73-16989 08-02)

Summaries of papers presented at the conference on flight qualities are presented. Topics discussed include: flying qualities for conventional and V/STOL aircraft, man-machine research, and the establishment of criteria. F.O.S.

**N73-16994** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif. **CONSIDERATIONS FOR STABILITY AND CONTROL OF V/STOL AIRCRAFT: A REVIEW OF AGARD REPORT 677**

Seth B. Anderson and Laurel G. Schroers (Army Mobility R and D Lab.). *In* AGARD Stability and Control Nov. 1972 10 p refs (For availability see N73-16989 08-02) CSCL 01B

Revisions which have been made to previous V/STOL handling qualities requirements based on criteria are discussed. A discussion of the pilot's desire for a particular characteristic is given. In addition, data and reference material are provided to back up the proposed criteria to permit the user to understand the limitations of the data on which the criteria are based. A review is included of several controversial areas including pitch control sensitivity, static longitudinal stability, roll control power, roll-yaw cross coupling, and vertical flight path control. Author

**N73-16995** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. **MISSION EFFECTS ON STABILITY AND MANEUVERABILITY**

Charles B. Westbrook. *In* AGARD Stability and Control Nov. 1972 12 p refs (For availability see N73-16989 08-02)

The relationship between the mission requirements of a

piloted aircraft and its stability and maneuverability are defined. The framework utilized in current U.S. Air Force handling qualities requirements, i.e., classification of aircraft, flight phases, levels, states, etc., is described. Examples of various aircraft designed for one mission and then utilized for other missions are given. A discussion is presented of the problems encountered when the detailed mission requirements are not clear, such as with V/STOL aircraft, reentry vehicles, etc. Problems encountered with off-design conditions and operation at the limits of the flight envelope are discussed with examples. The various methods open to the designer for achieving the proper compromises in design of an aircraft are outlined. Author

**N73-16996** British Aircraft Corp., Preston (England). Military Aircraft Div. **DESIGN CONSIDERATIONS FOR THE SATISFACTORY STABILITY AND CONTROL OF MILITARY COMBAT AEROPLANES**

B. R. A. Burns. *In* AGARD Stability and Control Nov. 1972 28 p refs (For availability see N73-16989 08-02)

Design criteria for achieving satisfactory stability and control for military aircraft are reviewed along with official requirements. Some of the difficulties of designing to meet the standards of these criteria are considered. Topics discussed include longitudinal stability and control, and lateral stability and control. Author

**N73-16997** Technische Hochschule, Darmstadt (West Germany). **THE EFFECTS OF THRUST CHARACTERISTICS ON LONGITUDINAL STABILITY IN SUPERSONIC FLIGHT**

G. Sachs. *In* AGARD Stability and Control Nov. 1972 15 p refs (For availability see N73-16989 08-02)

The influence of the variation of thrust with speed and height on the dynamic stability of the longitudinal motion in supersonic flight is shown. The effects directly related to thrust changes are described along with the effects due to pitching moments which, associated with thrust characteristics, depend on speed and height. The thrust influence on two methods of artificial stabilization of long-term modes is also investigated. Author

**N73-16998** Societe Nationale Industrielle Aerospatiale, Paris (France). Departement Recherche. **INFLUENCE OF THE MASS AND MASS DISTRIBUTION ON FLYING QUALITIES [INFLUENCE DE LA MASSE ET DE LA REPARTITION DE LA MASSE SUR LES QUALITES DE VOL]**

Marc Mesnieres. *In* AGARD Stability and Control Nov. 1972 9 p refs. *In* FRENCH (For availability see N73-16989 08-02)

Several techniques pertinent to determining the influence of mass and mass distribution on the handling qualities of aircraft are presented. Particular attention was given to lateral and longitudinal maneuverability and the influence of inertia on the principle axis tilt angle. Several examples using a Corvet aircraft are given. Transl. by E.H.W.

**N73-16999** Royal Aircraft Establishment, Bedford (England). Aerodynamics Dept. **THE ROLE OF THEORY AND CALCULATIONS IN THE REFINEMENT OF FLYING QUALITIES**

W. J. G. Pinsker. *In* AGARD Stability and Control Nov. 1972 13 p refs (For availability see N73-16989 08-02)

The present state of the art in handling qualities research and design is broadly surveyed with particular emphasis on the role of theory and paper studies in this field. The significance and scope of handling criteria is critically discussed as setting targets for flying qualities design. The capabilities and limitations of theory are then considered in such areas as derivative prediction, rigid-body stability and response calculations, predictions of stability under partial constraint and under active pilot control. Finally some general consideration is given to novel flying qualities problems associated with the introduction of stability and control augmentation systems. Author

**N73-17000** Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost, Aerodynamics Dept.  
**ADJUSTMENT OF FLYING QUALITIES BY WIND TUNNEL TESTING**

Tj. Schuringa. In AGARD Stability and Control Nov. 1972 7 p (For availability see N73-16989 08-02)

Two examples of the wind tunnel approach to the flying qualities of the Fokker F28 Fellowship aircraft are described, one dealing with the development of the elevator surface, and the other with the development of stall characteristics. Author

**N73-17001** Naval Air Systems Command, Washington, D.C. Advanced Technology Sector.  
**FLIGHT SIMULATION: A SIGNIFICANT AID IN AIRCRAFT DESIGN**

Ralph C. AHarrah. In AGARD Stability and Control Nov. 1972 17 p refs (For availability see N73-16989 08-02)

The role of flight simulation in the development of the S-3 and F-14 aircraft is described along with the facilities used. An appraisal is included of simulation technology as applied to aircraft design. Author

**N73-17002** Royal Aircraft Establishment, Bedford (England). Aerodynamics Dept.

**THE ROLE OF FREE-FLIGHT MODELS IN AIRCRAFT RESEARCH AND DEVELOPMENT**

R. Foll. In AGARD Stability and Control Nov. 1972 14 p refs (For availability see N73-16989 08-02)

The special features of free-flight models are discussed. Two examples are given of tests in the field of flight mechanics. Preparations are described for a program of tests which is about to start at RAE to investigate the low-speed stall and post-stall dynamics of aircraft. Attention is concentrated on the planning of the tests and the instrumentation and control system in the model. Some details are given of the model handling and retrieval systems. Author

**N73-17003** British Aircraft Corp., Preston (England). Commercial Aircraft Div.

**THE EFFECT OF ENGINE FAILURE AT SUPERSONIC SPEEDS ON A SLENDER AIRCRAFT: PREDICTED AND ACTUAL**

C. S. Leyman and R. L. Scotland. In AGARD Stability and Control Nov. 1972 8 p (For availability see N73-16989 08-02)

The effect of engine failure on the aerodynamic characteristics of a supersonic aircraft were studied. Topics discussed include: prediction of aircraft stability derivatives, prediction of forces and moments due to engine failure, preflight simulation experience, and flight test results. F.O.S.

**N73-17004** Aerospatiale Usines de Toulouse (France).  
**CALCULATION OF INDUCED LOAD BY VARIATION IN COURSE DURING ANY MANOEUVRE [CALCUL DES CHARGES INDUITES PAR LA CLEXIBILITE AU COURS D'UNE MANOEUVRE QUELCONQUE]**

A. Maran. In AGARD Stability and Control Nov. 1972 9 p. In FRENCH (For availability see N73-16989 08-02)

A general formula for calculating load influence on aircraft flexibility is presented along with illustrations. A comparison was made of the load effects in rigid and transverse flexible aircraft. Three maneuvers, - lifting moments and forces, checked pitching, and checked rolling - were used for the analysis.

Transl. by E.H.W.

**N73-17006\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**ACTIVE CONTROL OF AEROELASTIC RESPONSE**

A. Gerald Rainey, Charles L. Ruhlman, and Maynard C. Sandford. In AGARD Stability and Control Nov. 1972 8 p refs (For availability see N73-16989 08-02)

Conceptual and wind-tunnel programs leading to the development of technology for applying active controls to the suppression of flutter were studied to provide a powerful tool for required safety margins for flutter in future high-performance supersonic aircraft. The nature of flutter considerations in the

design of the U.S. SST prototype aircraft is described as an example of the type of application where active flutter suppression shows promise. Author

**N73-17006** Aeronautical Systems Div., Wright-Patterson AFB, Ohio. B-1 Airframe Div.

**PREDICTION OF AEROELASTIC HINGE MOMENT EFFECTS ON STABILITY AND CONTROLLABILITY**

John W. Carlson. In AGARD Stability and Control Nov. 1972 6 p (For availability see N73-16989 08-02)

The effect of aeroelastic deflections on the stability and control characteristics are studied. Some examples of difficulties are shown that have resulted in control problems and aircraft limitations. Methods of predicting hinge moments are reviewed and some of the problems that arise by the use of these methods are discussed. A program for the analysis of structural deformations is described which may be used to analyze many aeroelastic problems. Author

**N73-17007** Aeritalia, Turin (Italy).  
**CONSIDERATIONS ON THE MANUAL FLIGHT CONTROL DESIGN OF A MILITARY TRANSPORT AIRCRAFT**

Antonio Filisetti and Giuseppe Ferrati. In AGARD Stability and Control Nov. 1972 20 p refs (For availability see N73-16989 08-02)

Criteria for designing manual control systems for military transport aircraft are presented including a guide to the choice of the manual control parameter. Practical problems concerning the nonlinear hinge moments behavior and the control force scatter with the flight conditions are discussed. Aspects of matching manual operated ailerons with hydraulically driven spoilers are emphasized along with practical methods for designing spring-tab control surfaces. Author

**N73-17008** Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

**POWERED CONTROLS, INFLUENCE ON STABILITY AND MANEUVERABILITY**

Gerhard K. Kissel. In AGARD Stability and Control Nov. 1972 13 p (For availability see N73-16989 08-02)

The influence is discussed of powered controls on the dynamic and static behavior of modern high performance aircraft. The possibilities of improving the stability and maneuverability by interconnections in the various axes are considered, and an example for a modern fighter type aircraft is demonstrated. Author

**N73-17009** Boeing Co., Seattle, Wash.  
**FLY-BY-WIRE AND ARTIFICIAL STABILIZATION DESIGN**

R. L. Schoenman. In AGARD Stability and Control Nov. 1972 13 p (For availability see N73-16989 08-02)

The implementation of artificial stabilization to correct serious stability and control deficiencies is discussed for meeting the performance demands for aircraft which operate over a broad flight envelope such as VTOL, STOL, and SST. For this class of aircraft safety-of-flight is dependent on the integrity of these systems, and has resulted in the development of redundant system designs. The conventional SAS design approach is compared to that recommended for those vehicles which require augmentation for safety-of-flight. The impact of system redundancy on maintainability and operating costs is also discussed. A system is proposed which features integration of critical flight functions, and the use of digital computation to simplify system complexity. Author

**N73-17010** Royal Aircraft Establishment, Farnborough (England). Human Engineering Div.

**PILOT WORKLOAD: A CONCEPTUAL MODEL**

R. G. Thorne. In AGARD Stability and Control Nov. 1972 6 p (For availability see N73-16989 08-02)

A conceptual model is presented for the study of the situations when some of the crew, some of the time are unable to complete satisfactorily some of their tasks. A more realistic simulation of the difficult tasks is recommended. Author

**N73-17011** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

# THE ROLE OF THEORETICAL STUDIES OF FLIGHT DYNAMICS IN RELATION TO FLIGHT TESTING

H. H. B. M. Thomas /In AGARD Stability and Control Nov. 1972 13 p refs (For availability see N73-16989 08-02)

It is argued that calculations have an important role to play in the planning of, the conduct of, and the analysis of flight tests. This is especially true of those areas of flight testing which involve maneuvers near limiting flight conditions in which preflight calculations are invaluable in arriving at a clearer definition of the objective of a test. Provided the aerodynamic forces acting on the aircraft can be adequately and reliably represented, there is inherent difficulty about undertaking the solution of the equations of motion in an appropriate number of degrees of freedom with the aid of available digital computers. The real problem, therefore, lies in reducing to a manageable form the output of such computer studies and thereby achieving a deeper understanding of and a more ready interpretation of the results. As an illustrative example, the longitudinal motion of an aircraft involving an extended angle-of-attack range is considered. Author

# N73-17012\* National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif. FLIGHT TEST EXPERIENCE IN AIRCRAFT PARAMETER IDENTIFICATION

Chester H. Wolowicz, Kenneth W. Iliff, and Glenn B. Gilyard /In AGARD Stability and Control Nov. 1972 13 p refs (For availability see N73-16989 08-02)

An automatic method for determining stability and control derivatives from flight data is presented. The technique, a modification of the Newton-Raphson method for derivative extraction, has a priori provision that makes use of initial estimates of the derivatives and provides a means of checking the validity of the results. Recommendations for applications of the method are included. Author

# N73-17013 Aerospatiale Usines de Toulouse (France) UTILIZATION OF BLACK BOXES FOR IMPROVING THE CHARACTERISTICS OF PILOTAGE DURING THE AIRCRAFT DEVELOPMENT PHASE [UTILISATION DES BOITES NOIRES POUR AMELIORER LES CARACTERISTIQUES DE PILOTAGE DURANT LA PHASE DE DEVELOPPEMENT D'UN AVION]

R. Deque /In AGARD Stability and Control Nov. 1972 12 p in FRENCH (For availability see N73-16989 08-02)

Problems encountered while trying to modify the flight control system of the Concorde aircraft during the development phase are reported. They are (1) tendency of pilot engine to pump in a lateral direction during supersonic flight, (2) consecutive skid with motor breakdown at supersonic speed, and (3) control of the aircraft after cut off of the piloting gear. The modifications made to correct these problems are given. Transl. by E.H.W.

# N73-18023# Advisory Group for Aerospace Research and Development, Paris (France). TECHNICAL EVALUATION REPORT ON FLUID DYNAMICS PANEL SPECIALISTS MEETING ON FLUID DYNAMICS OF AIRCRAFT STALLING

R. C. Penkhurst (Royal Aircraft Estab., Teddington, UK) Nov. 1972 11 p refs Conf held at Lisbon, 26-28 Apr 1972 (AGARD-AR-49) Avail NTIS HC \$3.00

An evaluation of the fluid dynamics of aircraft stalling is presented. The aerodynamic characteristics of the aircraft stall at both low and high speeds are discussed. Particular reference is made to the design and operation of combat and transport aircraft, including buffet penetration and post-stall behavior. Major subject areas concern flight experience, flight testing, wind tunnel measurements, and theoretical prediction methods. The effects of three dimensional flow, the influence of sweep back, and the design and performance of light lift devices are analyzed. Author

# N73-18030# Advisory Group for Aerospace Research and Development, Paris (France). RECENT DEVELOPMENTS IN FLIGHT FLUTTER TESTING IN THE UNITED STATES. SUPPLEMENT TO THE MANUAL

# ON AEROELASTICITY, VOLUME 4, CHAPTER 10

E. F. Baird (Grumman Aerospace Corp.) and W. B. Clark (Grumman Aerospace Corp.) Dec. 1972 27 p refs Presented at 34th AGARD Struct. and Mater. Panel Meeting, Lyngby, Denmark, 11 Apr. 1972

(AGARD-R-596) Avail: NTIS HC \$3.60

Advances in the rapid and accurate determination of flutter characteristics through the use of high speed computers are discussed. Comments are presented on some flight flutter testing procedures in use and under development. A model matching technique is described. This technique reduces data analysis time and is compatible with relatively fast data acquisition. Results of model matching when applied to theoretical response data are presented and compared with actual flight flutter testing. Author

# N73-20023# Advisory Group for Aerospace Research and Development, Paris (France) A SUMMARY OF THE ANALYSIS OF GUST LOADS RECORDED BY COUNTING ACCELEROMETERS ON SEVENTEEN TYPES OF AIRCRAFT

I. W. Keynes (RAE Farnborough) Dec. 1972 713 p refs Presented at the 35th Struct. and Mater. Panel Meeting, Toulouse, France, 26 Sep. 1972

(AGARD-R-605; AGARD-586-Add) Avail: NTIS HC \$7.75

The collection and processing of gust load data obtained from counting accelerometers during twenty years of recording is described. Tables of the accelerations and equivalent gusts are presented, the latter having been calculated by both discrete and spectral gust models. The gust frequency distributions are discussed. Author

# N73-21008# Advisory Group for Aerospace Research and Development, Paris (France) ADVANCED ROTORCRAFT, VOLUME 1

Feb. 1973 237 p refs Presented at the 39th meeting of the Flight Mech. Panel of AGARD, Hampton, Va., 20-23 Sep. 1971 (AGARD-CP-121) Avail NTIS HC \$14.00

The proceedings of a conference on rotary wing aircraft developments are presented. The objectives of the symposium are given as (1) review of experiences gained from existing helicopter operations, (2) review of lessons obtained from flight tests of experimental helicopters, (3) discussion of the future of advanced rotorcraft, and (4) ground test facilities for research and development of new rotorcraft. For individual titles, see N73-21009 through N73-21030.

# N73-21009 Service Technique Aeronautique, Paris (France) TACTICAL FLIGHT OF HELICOPTER AND REPERCUSSIONS ON THE CONCEPTION [LE VOL TACTIQUE DE L'HELICOP-TERE ET LES REPERCUSSIONS SUR SA CONCEPTION]

M. Berthou /In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 5 p in FRENCH (For availability see N73-21008 12-02)

Certain reflections on the aspects of the problem of tactical helicopter flight are made in light of experience acquired in the domain of aeromobility. After having examined the tactical environment, research was done on the effects of such environments on helicopter performance. Transl. by E.H.W.

# N73-21010 Royal Aircraft Establishment, Bedford (England) THE OPERATION OF HELICOPTERS FROM SMALL SHIPS

J. B. B. Johnston /In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 15 p (For availability see N73-21008 12-02)

Procedures for operating helicopters from the decks of small ships are discussed. The subjects presented are (1) an overall view of the operation, (2) types of helicopters in use, (3) types of ships used, (4) problem of deck size and superstructure, (5) nature and effect of air flow around the ship, and (6) problem of ship motion. Preliminary flight tests to investigate the identified problems are reported. Author

# N73-21011 Societe Nationale Industrielle Aerospatiale, Paris (France) TEN YEARS EXPERIENCE WITH THE HELICOPTER FROM

**OPERATION IN FRENCH ARMY (DIX ANS D'EXPERIENCE AVEC LES HELICOPTERES EN OPERATION DANS LES ARMEES FRANCAISES)**

A. Renaud / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1972 3 p. In FRENCH (For availability see N73-21008 12-02)

Helicopter performance as determined by a ten year study in various military environments is reported. Data cover operational systems, special equipment, and various environmental situations including tactical operations. Helicopter support activities are also discussed.

Transl. by E.H.W.

**N73-21012 Service Technique Aeronautique, Paris (France) RELIABILITY AND SAFETY OF OPERATING MECHANICAL HELICOPTER PIECES (FIABILITE ET SECURITE EN OPERATION DES PIECES MECANQUES POUR HELICOPTERES)**

S. Berner / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 9 p. In FRENCH (For availability see N73-21008 12-02)

After determining the service life of the mechanical parts of a helicopter, fail safe system characteristics, qualifications of transmission box mechanisms, their initial contribution and potential utilization were determined. Fabrication materials and procedures from both Britain and the U.S. are compared.

Transl. by E.H.W.

**N73-21013 Army Aviation Systems Test Activity, Edwards, AFB, Calif. GREATER SAFETY, MAINTAINABILITY, AND RELIABILITY THROUGH IMPROVED HELICOPTER FLIGHT TESTING**

Gerald E. Swecker / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 15 p. refs (For availability see N73-21008 12-02)

Data obtained from helicopter flight test programs are presented. Greater safety, maintainability, and reliability are being assured through constantly improved flight testing techniques and the use of state-of-the-art instrumentation, data acquisition, and data reduction equipment. More stringent helicopter performance criteria are placing greater demands on the test agencies to devise new methods and procedures for collecting and analyzing data. Included are such programs as: (1) the AH-1G (Cobra) helicopter and a simplified approach to finding height loss during dive recovery from throttle chops; (2) recommendation of limiting AH-1G tail rotor control; (3) OH-6A g loads experienced at high frequencies during weapons firing; (4) recommended pilot cues to define a safe AH-1G envelope following engine failure; (5) investigation of large sideslip and pitch excursions following throttle chops in the TH-55 helicopter; (6) identification of requirements for AH-1G instrument-flight-rule (IFR) evaluation; (7) results from OH-58 and AH-1G helicopter height-velocity (H-V) (autorotational) testing with discussion of application to operational use; and (8) AH-1G maneuvering limits from return-to-target profiles. Tests conducted with the AH-1G helicopter determined return-to-target time, height lost during pullout from a dive, and other maneuvering characteristics. The concept of energy maneuverability has been established, and significant data have been added to the literature.

Author

**N73-21014 Naval Air Test Center, Patuxent River, Md. Rotary Wing Branch**

**A NEW LOOK AT HELICOPTER LEVEL FLIGHT PERFORMANCE**

Allen B. Hill / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 9 p. (For availability see N73-21008 12-02)

Helicopter level flight performance data are presented as power coefficient ( $C_{sub p}$ ) versus tip speed or advance ratio for a range of thrust coefficients ( $C_{sub t}$ ). This data presentation was developed from momentum and blade element theory. The power coefficient is a nondimensional expression for the main rotor shaft horsepower required. The main rotor shaft horsepower required consists of profile, parasite and induced power. The advance or tip speed ratio is a nondimensional ratio of flight and main rotor rotational speed. The thrust coefficient is a nondimensional expression for thrust required. It should probably be called the weight coefficient, since vertical drag is normally ignored, and thrust is replaced by gross weight. A representative classic helicopter level flight performance curve is presented.

Author

**N73-21015 Royal Aircraft Establishment, Bedford (England) SOME FLIGHT EXPERIMENTS ON THE XH-51 N HELICOPTER**

P. Brotherhood and C. A. James / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p. refs (For availability see N73-21008 12-02)

Flight tests of the XH-51N helicopter are reported. The tests were primarily concerned with helicopter stability and control. Several combinations of gyroscopes and control springs were evaluated. The principal effects of the changes in configuration were variations in control sensitivity and rotor damping. A variation in static stability due to a differently shaped gyro arm was reported.

Author

**N73-21016 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany) INFLUENCE OF ELASTIC COUPLING EFFECTS ON THE HANDLING QUALITIES OF A HINGELESS ROTOR HELICOPTER**

G. Reichert and H. Huber / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 15 p. refs (For availability see N73-21008 12-02)

Stability and control of a helicopter with a hingeless rotor system is mainly influenced by the elastic flapping motion of the rotor blades. On a rotor with torsionally flexible blades or elasticity in the control system there can be additional aeroelastic effects, which act as control inputs on the blades. After a short description of the rotor system and the analytical model, the reasons and the influences of elastic coupling effects on the stability and control behavior of a hingeless rotor helicopter are discussed. There are effects which result from the aerodynamic characteristics and from the chordwise mass distribution on the blade. Additional coupling effects result from flapping and inplane deflections out of the pitching control axis similar to a pitch-flap coupling. Theoretical results are compared with flight test data.

Author

**N73-21017 Westland Helicopters, Ltd., Yeovil (England) GROUND AND FLIGHT TEST EXPERIENCE WITH THE WESTLAND SCOUT HINGELESS ROTOR HELICOPTER**

D. E. H. Balmford / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p. (For availability see N73-21008 12-02)

The flight test experience gained during the basic clearance of a Westland Scout helicopter fitted with a reduced scale version of the hingeless rotor system is discussed. The basic clearance was aimed at producing an aircraft with sufficient capability to embark upon a series of research tasks and as such was devoted to investigating the airworthiness and handling of the aircraft broadly within the limit of the flight envelope of the standard production Scout fitted with an articulated rotor. Provided that these limits could be approached reasonably closely it was considered that the aircraft would be adequate for its research tasks. A statement of the present status of flight testing of the Lynx helicopter is included.

Author

**N73-21018 Societe Nationale Industrielle Aerospatiale, Paris (France) SOME THOUGHTS ON THE SA 341 GAZELLE SPEED RECORD**

J. Soulez-Larriere / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 4 p. (For availability see N73-21008 12-02)

The speed record establishment for helicopters by the SA 341 helicopter is discussed. The nature of the course flown and the requirements for successful completion are described. The preparation of the helicopter for the record try is reported. Lessons to be drawn from this experience for future record tries are analyzed.

Author

**N73-21019 Army Air Mobility Research and Development Lab., Moffett Field, Calif. PROGRESS IN ROTOR-BLADE AERODYNAMICS**

P. F. Yeggy and I. C. Stetler / In AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 15 p. refs (For availability see N73-21008 12-02)

The primary factors inhibiting the performance of rotary wing aircraft are identified. The inhibiting factors are examined and

discussed with respect to developments in the aerodynamics of the rotor, the mathematical modeling of its wake, and the prediction of dynamic airloads and their effects on flying qualities. Recent developments in rotor flow studies, rotor blade pressure distributions, rotor blade boundary layer analyses, airfoil behavior in rotors, and rotor aerodynamics are presented.

Author

**N73-21020** Army Air Mobility Research and Development Lab., Fort Eustis, Va. Structures Div.  
**SURVEY OF ROTARY WING LOADS AND STABILITY ANALYSIS PROBLEMS**

H. I. MacDonald *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 6 p (For availability see N73-21008 12-02)

A survey of some of the problems encountered in the prediction of structural design loads and aeroelastic stability margins during the development of rotary wing aircraft is presented. The importance of accurate prediction of structural design loads for improved reliability performance, and stability of aircraft is stressed. Variations in analysis methods employed by various manufacturers are discussed. The complexity involved in the prediction of rotary wing loads and aeroelastic stability, the effects on cost effectiveness, and areas where complex analysis is advantageous are reported.

Author

**N73-21021** United Aircraft Corp., Stratford, Conn.  
**IMPACT OF NEW STRUCTURAL CONCEPTS ON SYSTEM CAPABILITIES**

Edward S. Carter *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 11 p refs (For availability see N73-21008 12-02)

The impact of structural concepts on rotary wing system capabilities is examined. Current vertical takeoff aircraft system capabilities in terms of payload and gross weight ratio are reported. Examples of advances in vertical takeoff aircraft design are submitted. Specific developments in rotor blade construction, variable geometry concepts, drive systems, transmissions, and airframes are presented.

Author

**N73-21022** Boeing Co., Philadelphia, Pa. Vertol Div.  
**EVALUATION, DEVELOPMENT, AND ADVANTAGES OF THE HELICOPTER TANDEM DUAL CARGO HOOK SYSTEM**

Gregory J. Wilson and Newton N. Rothman *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 8 p refs (For availability see N73-21008 12-02)

Helicopter transport of external cargo for military applications, efficient use of available rotary-wing equipment, and enhancement of aircraft safety is examined. Improvements in this technique could provide the transport of external cargo at the maximum speed of the helicopter, routine operation under instrument flight rules (IFR), precise placement of the load, and could eliminate the problems in hover such as the dust cloud and static electricity. Feasibility studies have shown the potential of the tandem dual hook concept as a viable base on which to build an improved cargo-handling system. Production incorporation of a dual cargo hook system is planned for the heavy-lift helicopter (HLH). The system incorporates other features such as variable longitudinal hook positioning, differential winching, load motion feedback, and augmentation of the cargo system operator's vision under conditions of poor light and thick dust. The requirements for an improved helicopter external cargo-handling system, the programs which have established the feasibility of a tandem dual cargo hook system, and the system slated for the heavy-lift helicopter are reported.

Author

**N73-21023** Westland Helicopters, Ltd., Yeovil (England)  
**MATERIALS FOR ADVANCED ROTORCRAFT**

J. P. Jones *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 6 p refs (For availability see N73-21008 12-02)

The development and application of composite materials for constructing airframes of vertical takeoff aircraft are discussed. The properties of carbon reinforced plastics are described and specific areas of application for airframes and rotors are identified. The design features which produce better handling qualities of rotary wing aircraft and which are possible by the use of improved composite materials are examined.

Author

**N73-21024** Hawker Siddeley Aviation, Ltd., Woodford (England)  
**STOPPED ROTOR AIRCRAFT USING CIRCULATION CONTROLLED ROTORS**

John Taylor *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 15 p refs (For availability see N73-21008 12-02)

The fundamental problems of the stopped rotor aircraft are examined. The aerodynamic characteristics of the circulation controlled rotor are discussed and the results of test data presented. Finally, the evolution of a typical stopped rotor aircraft design using circulation controlled rotors is illustrated.

Author

**N73-21025** Giravions Dorand Co., Paris (France)  
**FIELDS OF APPLICATION OF JET FLAPPED ROTORS**

M. Kretz *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p refs (For availability see N73-21008 12-02)

Analysis of the field of application of the jet-flap rotor shows the cost-effectiveness of this technique when applied to heavy helicopter and stoppable rotor designs. Comparison with equivalent mechanically driven heavy-lift rotorcraft shows empty-weight gains of 30 to 40 percent. Initial cost gains for these vehicles is even higher, approaching 50 percent. The feasibility of an aircraft having a 0.85 Mach number capability and possessing a stoppable and stowable nonfolding two-bladed rotor has been established. The weight analysis also demonstrates the attraction of the jet-flap concept, which combines the features of both low weight and low cost, with a long duration hovering capability. The jet-flap rotor thus makes it possible for the same aircraft to have the high airspeed characteristics of a modern airplane coupled with the low-speed advantages of a helicopter.

Author

**N73-21026** Dornier-Werke G m b H., Friedrichshafen (West Germany)  
**RESEARCH AND DEVELOPMENT ON ROTORS WITH TIP REACTION DRIVE IN GERMANY**

Christoph Fischer *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p refs (For availability see N73-21008 12-02)

Activities on cold, hot and mixed cycle tip jet propulsion for rotors are reported. Research and programs on cold and large mixed cycle systems are described. For both projects some results of component testing flight tests are discussed. Aspects of the flight mechanics as decoupling of movements in hovering and advantages of wide rpm-range are shown. Concluding remarks on the operational applicability and new missions favoring torque-free rotor drive systems are added.

Author

**N73-21027** Boeing Co., Philadelphia, Pa. Vertol Div.  
**SURVEY OF TILT ROTOR TECHNOLOGY DEVELOPMENT**

K. B. Gilmore *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 11 p refs (For availability see N73-21008 12-02)

A review is made of the development of tilt rotor technology since the XV-3 program in the late 1950's. A brief comparison of the capabilities of the tilt rotor with other rotary wing configurations for a transport mission is shown. Tilt rotor performance and dynamic model tests are described. Analytical methodology development is reviewed and predictions are shown to compare well with model test data in the areas of performance, aeroelastic stability and flying qualities. It is concluded that the technology is now in hand to develop a prototype vehicle.

Author

**N73-21028** Societe Nationale Industrielle Aerospatiale, Marignane (France)  
**FENESTRON: NEW SOLUTION OF TAIL ROTOR [LE FENESTRON, SOLUTION NOUVELLE DE ROTOR DE QUEUE]**

J. Gallot *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 7 p *In* FRENCH (For availability see N73-21008 12-02)

A method for determining flight performance and flight qualities of a Fenestron type tail rotor is presented. Data cover vulnerability, effects of vibration on stationary flight performance, flight control, and maintenance.

Transl. by E. H. W.

**N73-21029** United Aircraft Corp., Stratford, Conn.  
**DEVELOPMENT OF THE ABC ROTOR**

Robert K. Burgess *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 17 p refs (For availability see N73-21008 12-02)

The development of the advancing blade concept (ABC) rotor

is traced from conception through small scale model wind tunnel testing, full scale analysis, design, fabrication and ultimate wind tunnel testing of a 40 ft diameter rotor. The principal design tradeoffs resulting from the early analysis and testing are discussed along with their expected impact on the full scale rotor characteristics. Materials and manufacturing methods employed are covered including the more important difficulties that were surmounted during the nearly five years of development. Finally, the major test programs are outlined including blade balancing, turbine test bed operation and full scale wind tunnel testing facility up to speeds of 180 knots and advance ratios of 9.1. Significant results of these tests are presented, and applications in aircraft systems discussed. Author

**N73-21030 Royal Aircraft Establishment, Bedford (England)  
RAE EXPERIENCE IN THE USE OF A PILOTED GROUND-  
BASED SIMULATOR FOR HELICOPTER HANDLING  
STUDIES**

T. Wicoma. In AGARD Advanced Rotocraft, Vol. 1 Feb. 1973 12 p refs (For availability see N73-21008 12-02)

Two studies using a ground-based piloted flight simulator for the assessment of helicopter handling qualities are described. The first simulation, of a Westland Wessex, was performed to establish the simulation techniques required for effective representation of handling behaviour. The second study was of the Westland Lynx, and was conducted prior to the first flight of that helicopter in order to provide assistance in the early development program. Results of the two simulations are discussed, and the experience gained from these tests is used to suggest some requirements for valid simulation. Author

**N73-21031# Advisory Group for Aerospace Research and  
Development, Paris (France)  
AERODYNAMICS OF ROTARY WINGS**

Feb 1973 449 p refs In ENGLISH partly in FRENCH Presented at Fluid Dyn. Panel Specialists Meeting, Marseilles, 13-15 Sep 1972

(AGARD-CP-111) Avail. NTIS HC \$24.50

The proceedings of a conference on the fluid dynamics of rotary wings and methods for calculation and analysis of the aerodynamics and dynamics of rotary wing systems are presented. The subjects discussed include the following: (1) calculation of rotor wake characteristics and inflow distribution, (2) factors affecting performance at hover and high advance ratio, (3) description of analytical methods for calculating rotor unsteady aerodynamics, (4) trends in rotor blade airfoil design, and (5) measurement of aerodynamic noise generated by rotary wings. For individual titles, see N73-21032 through N73-21056

**N73-21032 United Aircraft Corp., East Hartford, Conn.  
ROTOR WAKES: KEY TO PERFORMANCE PREDICTION**  
Anton J. Landgrebe and Marvin C. Cheney, Jr. In AGARD  
Aerodyn. of Rotary Wings Feb. 1973 19 p refs (For availability  
see N73-21031 12-02)

The history of helicopter performance prediction methods and the influence of rotor wakes are traced from the simple momentum techniques used in the early years of propellers and rotors to the current state-of-the-art computer programs simulating the rotor's complex vortex structure. Analytical and experimental techniques are described which define the geometry of the vortex field of a hovering rotor and its effect on rotor

performance. It was concluded that the most important factor which influences the prediction of hover performance was the interference caused by the tip vortex during its first revolution. Integrated performance in forward flight was generally not sensitive to variable inflow, however, when combined with unsteady airfoil data, variable inflow produced significant effects on blade torsional responses. Author

**N73-21033 Army Air Mobility Research and Development Lab.,  
Moffett Field, Calif.  
AN ACTUATOR DISC THEORY FOR ROTOR WAKE  
INDUCED VELOCITIES**

Robert A. Ormiston. In AGARD Aerodyn. of Rotary Wings Feb. 1973 19 p refs (For availability see N73-21031 12-02)

A general actuator disc theory is presented for predicting the time-averaged downwash distribution, and steady state force

and moment response characteristics of helicopter rotors in forward flight. Particular attention is given to a proper definition of the rotor potential flow problem. The formulation of the theory is conceptually based on classical fixed wing lifting line theory to enhance its versatility and provide insight about the complex physical features of the rotor downwash distribution. The method of solution expresses the rotor downwash in a Fourier series where the coefficients are given as a summation of influence functions. It is shown that the rotor wake vorticity can be assumed to lie in a flat planar wake for a wide range of flight conditions, thus simplifying the Biot-Savart integration for the downwash. The vorticity elements in the flat planar wake are decomposed into simple circular and linear elements to further simplify the integrations. Author

**N73-21034 Westland Aircraft, Ltd., Yeovil (England)  
THE STRUCTURE OF THE ROTOR BLADE TIP VORTEX**

C. V. Cook. In AGARD Aerodyn. of Rotary Wings Feb. 1973 14 p refs (For availability see N73-21031 12-02)

The results of a set of experiments to measure the velocity distribution through a helicopter rotor blade tip vortex are presented. The experiments were conducted on a single full scale rotor blade operating at a representative tip speed on a whirl tower. The rotor was mounted in the inverted position (thrusting downward) to reduce the ground effects and produce a steady flow through the rotor. The vortex velocity distributions were measured for a range of vortex ages and a number of blade loadings, the highest of which was above that normally associated with a hovering rotor. A vortex 'age' range in terms of blade rotation of approximately 70 to 380 degrees of azimuth was covered. Flow visualization using smoke was employed to determine the trajectory of the vortex and a hot wire anemometer to measure the induced velocities associated with the tip vortex. Author

**N73-21035 Georgia Inst. of Tech., Atlanta School of Aerospace  
Engineering  
A VORTEX ANALYSIS OF A SINGLE BLADED HOVERING  
ROTOR AND A COMPARISON WITH EXPERIMENTAL DATA**

Robin B. Gray and George W. Brown. In AGARD Aerodyn. of Rotary Wings Feb. 1973 14 p refs (For availability see N73-21031 12-02)

A theoretical method is developed for determining the geometry and strength distribution of the vortex wake generated by a single-bladed hovering helicopter rotor. The analysis begins with a simple model of the ultimate wake geometry and then proceeds to establish the corresponding nondimensional tip-vortex strength. This simple vortex-wake model is adjusted by procedures that are based on the Biot-Savart law to obtain a first approximation for the tip-vortex geometry. Next, an estimate of the blade collective pitch angle is found from blade-element considerations. Then, a first approximation for the geometries and strengths of the vortex-sheet filaments that are shed from the blade trailing edge is determined by marching inboard from the blade tip. Thus, a simultaneous solution for the filament strengths is not required. Further adjustments to the wake geometry, the strengths of the inboard filaments, and the collective pitch are made until succeeding changes become acceptably small. Author

**N73-21036 Societe Nationale Industrielle Aerospatiale, Marseille  
(France)  
ROTOR STATIONARY FLIGHT AND LARGE ADVANCEMENT**

**PARAMETERS (ROTOR EN VOL STATIONNAIRE ET A  
GRAND PARAMETRE D'AVANCEMENT)**

J. Soulez-Lanviere. In AGARD Aerodyn. of Rotary Wings Feb. 1973 29 p In FRENCH (For availability see N73-21031 12-02)

A technique which permits vertical flight by a helicopter rotor is disclosed. The historical development of a conduit is explored, after which the diverse shock limitations on stationary and translation flight are examined. A historical account is also given of the methods used to improve and calculate the performance of helicopter rotors. Transl. by E.H.W.

**N73-21037 Societe Nationale Industrielle Aerospatiale, Marseille  
(France)  
ROTOR REQUIREMENTS BEYOND THE USUAL FLIGHT**

**DOMAIN OF ONERA LARGE WIND TUNNEL AT MONDANE**  
**[COMPORTEMENT D'UN ROTOR AU-DELA DU DOMAINE**  
**DE VOL USUEL A LA GRANDE SOUFFLERIE DE MONDANE]**  
 Michel Lecarme *In* AGARD Aerodyn of Rotary Wings Feb 1973 14 p. In FRENCH. ENGLISH summary (For availability see N73-21031 12-02)

Several series of tests have been performed on a 4.150 meter diameter experimental rotor in the large wind tunnel. The blades stiffness and available power of test equipment in the wind tunnel made a number of measurements and visualizations possible in some severe configurations and at high tip speeds. During the exploration of the test envelopes for various sets of blades, a tip speed ratio of 87 was reached, the retreating blade stall was studied at several values of preset parameters, such as: wind speed, rotor tip speed, rotor shaft tilt, and collective pitch. The present rotor head is not provided with cyclic pitch control. Operating limits for a conventional rotor were determined in terms of tip speed ratio. Development of retreating blade stall is affected by the reverse flow area and vortex interactions and this stall produces disturbances which increase as the tip speed ratio decreases. Author

**N73-21038** United Aircraft Corp., Stratford, Conn. Sikorsky Aircraft Div

**AERODYNAMIC FACTORS INFLUENCING OVERALL HOVER PERFORMANCE**

Evan A. Fradenburgh *In* AGARD Aerodyn of Rotary Wings Feb 1973 11 p. refs (For availability see N73-21031 12-02)

Improvements in basic rotor design practice are described and results of several series of model rotor tests are discussed. Moderate values of blade root cutout are shown to have an unanticipated effect on hovering efficiency. A large root cutout decreases figure of merit of the rotor, but also reduces vertical drag of a typical airframe below the rotor, cutting the aerodynamic penalty to about half of what tests of the rotor alone would indicate. Tests of a tilt-rotor model show that, unlike the conventional single rotor helicopter configuration, the rotors do not benefit from a partial ground effect caused by the airframe in the rotor downwash field. The relationship of blade twist and ground effect is discussed, and the influence of ground proximity on vertical drag is presented. It is shown that net airframe vertical drag can be zero or negative when the aircraft is close to the ground. Additional systematic experimentation is clearly needed, as is the development of theory to cover the various relationships involved in overall hover efficiency. Author

**N73-21039** Dornier-Werke GmbH, Friedrichshafen (West Germany)

**THE ROTOR IN AXIAL FLOW**

Herbert Zimmer *In* AGARD Aerodyn of Rotary Wings Feb 1973 16 p. refs (For availability see N73-21031 12-02)

The aerodynamic characteristics of rotary wings under axial flow conditions are discussed. An outline of the calculation methods is given. A vortex method is used for one type of calculation. A momentum blade element method is applied in another case because of the widely separated flow. Emphasis is placed on quick solution of the equations because of the need for frequent use in a design cycle and during performance calculations. Author

**N73-21040** Canadair Ltd., Montreal (Quebec)

**THE DEVELOPMENT OF AN EFFICIENT HOVERING PROPELLER: ROTOR PERFORMANCE PREDICTION**

**METHOD**

D. C. Gilmore and I. S. Gantshore (British Columbia Univ.) *In* AGARD Aerodyn of Rotary Wings Feb 1973 24 p. refs (For availability see N73-21031 12-02)

The development of a method for predicting the performance of heavily loaded propellers and rotors in steady hovering flight is described. The method has two particularly useful characteristics: (1) certain simplifying assumptions which allow consistency in the analytical model to be achieved with only a few small scale iterations and (2) a need for only a part of the wake to be specified. The analytical model built up from three basic elements, includes a single vortex filament shed from the tip of each blade, a vortex sheet shed inboard of the point of maximum

bound circulation on each blade, and an outboard sheet rolling up to form the tip vortex at an arbitrary angle. Roll-up angle affects the circumferential variation of induced velocity components but not their mean values. Application of the method to three propellers shows that accuracy of results is dependent upon realism of the assumed wake geometry. Author

**N73-21041\*** National Aeronautics and Space Administration Langley Research Center, Langley Station, Va.  
**A SUMMARY OF CURRENT RESEARCH IN ROTOR UNSTEADY AERODYNAMICS WITH EMPHASIS ON WORK AT LANGLEY RESEARCH CENTER**

John F. Ward and Warren H. Young, Jr. *In* AGARD Aerodyn of Rotary Wings Feb 1973 20 p. refs. Prepared in cooperation with Army Air Mobility R and D Lab., Fort Eustis, Va. (For availability see N73-21031 12-02)

The basic unsteady aerodynamic environment of the rotary wing is summarized. Some of the observed trends in the state of the art are discussed. Some of the research needs that will require attention are reported. A review of a number of research investigations as a part of a joint NASA/Army rotorcraft project is presented. The research is directed toward achieving a better understanding of rotor unsteady airfoils. The investigations include: (1) rotor maneuver loads, (2) level flight and maneuver wake prediction, (3) tip-vortex flow, (4) blade-vortex interactions, (5) dynamic stall, (6) transient Mach number air loads, and (7) development of variable geometry rotors. Author

**N73-21042** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

**AERODYNAMIC FORCES COMPUTATION AND MEASUREMENT ON AN OSCILLATING AEROFOIL PROFILE WITH AND WITHOUT STALL**

J. J. Philippe and M. Segner *In* AGARD Aerodyn of Rotary Wings Feb 1973 13 p. refs. In FRENCH. ENGLISH summary (For availability see N73-21031 12-02)

Research projects on computing and measuring aerodynamic forces on oscillating airfoil profiles are discussed. The problems created by unsteady aerodynamic stalling of rotary wings are emphasized. The experimental findings are analyzed as a function of mean angle of attack, oscillations amplitude, reduced frequency, and Mach number. Computed results are compared with experimental data. Author

**N73-21043** Aix-Marseille Univ. (France) Inst de Mecanique des Fluides

**AERODYNAMIC EFFORTS ON A LARGE WING PROFILE WITH QUICK HARMONIC MOVEMENT PARALLEL TO SIEVE FLOW [EFFORTS AERODYNAMIQUES SUR UN PROFIL D'AILE ANIME D'UN MOUVEMENT HARMONIQUE PARALLELE A L'ECOULEMENT MOUVEMENT DE TAMIS]**

J. Valensi and J. Rebont (CNRS) *In* AGARD Aerodyn of Rotary Wings Feb 1973 14 p. refs. In FRENCH (For availability see N73-21031 12-02)

The effects of drag, lift, and pitching moments on a rectangular wing profile system were measured. Measurements were taken at different incidences and different values of advancement parameters. Transl. by E.H.W.

**N73-21044\*** National Aeronautics and Space Administration Langley Research Center, Langley Station, Va.

**A COMPRESSIBLE UNSTEADY THEORY FOR HELICOPTER ROTORS**

Charles E. Hammond and G. Alvin Pierce (Ga Inst of Tech) *In* AGARD Aerodyn of Rotary Wings Feb 1973 15 p. refs. Prepared in cooperation with Army Air Mobility Res. and Develop. Lab., Ft. Eustis, Va. (For availability see N73-21031 12-02) (Contract DAHCO4 68 C 0004)

An aerodynamic theory is presented which allows the determination of the unsteady aerodynamic loading on a reference section of a helicopter rotor blade in axial or hovering flight under compressible flow conditions. The aerodynamics of the two-dimensional flow model are formulated using a kernel function approach. By introducing the acceleration potential the governing integral equation for the flow and its attendant downwash boundary condition are developed and solved numerically using

a pressure mode assumption and a collocation technique. The compressible aerodynamic theory thus developed is compared analytically with two other existing theories, one incompressible and one compressible, and is shown to agree with these theories provided that the appropriate limit is taken so that the flow models agree. The ratio of blade oscillatory frequency to rotor rotational frequency is shown to be the correlation parameter between the two flow models. Author

**N73-21045** Messerschmitt-Boelkow-Blohm G m b H, Ottobrunn (West Germany)

#### SOME ASPECTS OF THE DESIGN OF ROTOR-AIRFOIL SHAPES

G Reichert and S N Wagner. In AGARD Aerodyn of Rotary Wings. Feb 1973. 22 p. refs (For availability see N73-21031 12-02)

Analytical studies have shown that performance, stability and control of helicopters can be improved if some characteristics of rotor airfoils could be changed. Starting from given airfoil shapes the characteristics of these airfoils are idealized by changing lift curve slope, maximum lift boundary and beginning of drag divergence. The influences of these changes on the power required, the stability and control of hingeless rotor helicopters are studied. Furthermore, the desirable characteristics of an airfoil or several airfoils of a rotor are defined using these idealized characteristics and analysing common missions of a given helicopter. Similar studies of a larger field of missions and helicopters could lead to new areas of research and development to design advanced profile shapes of helicopters of the future. Several analytical tools for the design of airfoils are discussed. Author

**N73-21046** Army Air Mobility Research and Development Lab., Moffett Field, Calif.

#### RECENT DEVELOPMENTS IN ROTOR BLADE STALL

W J McCroskey. In AGARD Aerodyn of Rotary Wings. Feb 1973. 13 p. refs (For availability see N73-21031 12-02)

Developments in techniques for analyzing boundary layers of rotor wings are discussed. The basic effects of rotation and crossflow due to forward flight have been identified and found to be insignificant for most cases of practical interest in helicopter aerodynamics. Within the framework of classical thin boundary theory, unsteady viscous effects are also small. Unsteady viscous-inviscid interaction appears to play an important role in retreating blade stall. The characteristics of retreating blade stall are described based on vortex-like disturbance from the leading edge of the rotor blade. Author

**N73-21047** Royal Aircraft Establishment, Farnborough (England). THE DERIVATION AND VERIFICATION OF A NEW ROTOR PROFILE ON THE BASIS OF FLOW PHENOMENA, AEROFOIL RESEARCH AND FLIGHT TESTS

H H Pearcey, P G Wilby, M J Riley, and P Brotherhood. In AGARD Aerodyn of Rotary Wings. Feb 1973. 18 p. refs (For availability see N73-21031 12-02)

An account is given of some of the considerations that governed the derivation of new profiles to be incorporated in the design of the rotor blades for the Lynx helicopter at its inception. The changes relative to the NACA 0012 profile were conservative but were chosen to give consistent and significant all-round improvements to the shock-induced limits on the advancing blade to the retreating blade thrust limits and to the loading that could be sustained without shock wave drag in hover. The conservatism applied especially to the stalling characteristics which play such a dominant part in limiting rotor performance but which are so difficult to predict for the rotor environment. The profiles were derived on the basis of steady flow aerofoil tests, but qualitatively similar improvements have been verified in oscillatory aerofoil tests and in flight. A technique used in the latter tests is described for measuring pressure distributions along the blade chord and across the blade wake in the region of the rotor tip in flight. Author

**N73-21048** Army Air Mobility Research and Development Lab., Moffett Field, Calif.

#### THE EFFECT OF PLANFORM SHAPE ON THE TRANSONIC FLOW PAST ROTOR TIPS

W F Ballhaus and F X Caradonna. In AGARD Aerodyn of Rotary Wings. Feb 1973. 12 p. refs (For availability see N73-21031 12-02)

A numerical relaxation algorithm capable of calculating the transonic inviscid flow about arbitrary planform rotors has been developed. The essential feature of this method is a transformation in which arbitrary planforms are converted to rectangles and all boundary condition problems are transferred to the equation of motion. Preliminary numerical calculations are presented for blades of various sweeps and profiles. It is seen that three-dimensional effects remove sweep effects and can cause shocks which are locally more severe than would occur in less swept or even unswept planforms. The method presents itself as a means of checking various rotor configurations before any tests are made. Author

**N73-21049\*** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

#### A SUMMARY OF WIND TUNNEL RESEARCH ON TILT-ROTORS FROM HOVER TO CRUISE FLIGHT

Ph Poisson-Quinton and W L Cook. In AGARD Aerodyn of Rotary Wings. Feb 1973. 16 p. refs (For availability see N73-21031 12-02)

An experimental research program conducted on a series of tilt rotors designed for a range of blades twist is reported. The test facilities used in the program are identified. The objective of the program was to obtain precise results on the influence of blades twist and aeroelasticity on tilt rotor performance from hover to high speed cruise Mach number to 0.7. Five aluminum rigid rotors and one fiber glass composite rotor were tested. Author

**N73-21050** Naval Ship Research and Development Center, Bethesda, Md.

#### RECENT DEVELOPMENTS IN CIRCULATION CONTROL ROTOR TECHNOLOGY

Robert Williams. In AGARD Aerodyn of Rotary Wings. Feb 1973. 19 p. refs (For availability see N73-21031 12-02)

Research on the historical concept of circulation control applied to rotor blades is presented. A high speed helicopter application is used to illustrate the potential of this rotor for a major breakthrough in the areas of rotor efficiency, parasite drag and weights leading to a large improvement in aircraft productivity. Details of the hover, transition and high speed cruise performance are presented. Some problems of autorotation, vibrations and blade dynamics are also discussed. Author

**N73-21051** Messerschmitt-Boelkow-Blohm G m b H, Ottobrunn (West Germany).

#### SOME OBJECTIVES IN APPLYING HINGELESS ROTORS TO HELICOPTERS AND V/STOL AIRCRAFTS

H B Huber. In AGARD Aerodyn of Rotary Wings. Feb 1973. 16 p. refs (For availability see N73-21031 12-02)

Some of the aerodynamic, dynamic and aeroelastic problems in rotor design for helicopters and V/STOL aircraft are discussed. After a short description of the main features of the hingeless rotor concept the most important research and design areas of the system are indicated. Attention is given to the flapping and inplane stiffness of the blade root section, the aerodynamic and dynamic blade design, the rotor hub geometry and the control system flexibility. The aeroelastic characteristics and some important parameter sensitivities are reported. The analytical and experimental studies include control and flight dynamic characteristics, structural loads, damping behaviour and aeroelastic stability. Analytical results are compared with test data. Based on these results some design criteria are provided and recommendations are made for a successful application of hingeless rotor systems on helicopters and tilting prop/rotor aircraft. Author

**N73-21052** SIAI Marchetti S.p.A., Varese (Italy).

#### AERODYNAMICS OF HELICOPTER COMPONENTS OTHER THAN ROTORS

Angelo Bosco. In AGARD Aerodyn of Rotary Wings. Feb 1973. 16 p. refs (For availability see N73-21031 12-02) (Contract DAJ437-72 C-1998)



The effects of parameters other than rotary wings on the performance of helicopters are discussed. Specific examples for the design of the SV-20A winged helicopter are presented. Wind tunnel tests to isolate aerodynamic interferences and to confirm aerodynamic analyses are described. The application of nonrotating component aerodynamics to optimization of the helicopter design is reported. Author

**N73-21063\*** Loughborough Univ. of Technology (England)  
**FUNDAMENTAL CONSIDERATION OF NOISE RADIATION BY ROTARY WINGS**

Martin V. Lowson. In AGARD Aerodyn. of Rotary Wings. Feb. 1973. 18 p. refs. Sponsored by NASA and Natl. Gas Turbine Estab. (For availability see N73-21031 12-02)

An historical review of progress in understanding of rotor noise is presented. Initial work was principally on propellers, but has many obvious applications to noise from rotary wings. Current understanding of rotor noise radiation is then reviewed in some detail. The principal noise sources appear to be (1) discrete frequency due to distorted inflow, (2) low frequency broadband due to turbulent inflow, and (3) high frequency broadband due to tip effects. On a helicopter rotor each of these sources seems to be intimately connected with the shed vortex wakes. Tip modifications offer one method for controlling the effects. The implications for the designer are discussed. Rotor subjective noise levels appear to obey a velocity to the eighth power law, independent of thrust. Experiments to rectify some of the present deficiencies in knowledge are suggested. Author

**N73-21064** Bogazici Univ., Istanbul (Turkey)  
**WAKE CHARACTERISTICS OF A TWO DIMENSIONAL ASYMMETRIC AEROFOIL**

Ibrahim Kavrak. In AGARD Aerodyn. Rotary Wings. Feb. 1973. 7 p. refs. (For availability see N73-21031 12-02)

The process by which dipole noise is generated by the turbulent wake behind an airfoil is discussed. The characteristics of the wake are investigated and compared to the drag and lift coefficients as well as the noise radiated. It is concluded that both the drag coefficient and the generated noise are closely related to the turbulent shear in the separated flow area. The maximum velocity defect is shown to be an important parameter which affects both the performance and the noise intensity. Author

**N73-21065** Societe Nationale Industrielle Aerospatiale, Marseille (France)  
**MEASURE OF HELICOPTER NOISE DURING FLIGHT [MESURES DE BRUIT D'HELICOPTERES EN VOL]**  
Fernand Dambra, Jean-Pierre Dedieu, and Alain Julienne (ONERA, Chatillon, France). In AGARD Aerodyn. of Rotary Wings. Feb. 1973. 15 p. refs. In FRENCH. ENGLISH summary. (For availability see N73-21031 12-02)

Noise measurements have been performed on several helicopters. These tests were aimed toward a complete survey of helicopters' internal and external noise levels in several flight conditions. Data analysis of flyover tests follows conventional aircraft's acoustical certification procedure. Test results are corrected to duplicate nominal flight path and standard atmosphere conditions in several noise units. A statistical analysis of maximum noise levels has been performed and results are presented with their confidence level. The use of the trajectography equipment grants in addition the exact timing of acoustical spectra from which directivity patterns of noise radiated from the complete aircraft in flight and from particular noise sources can be obtained. Author

**N73-21066** Westland Helicopters, Ltd., Yeovil (England)  
**THE NOISE CHARACTERISTICS OF A LARGE CLEAN ROTOR**

John W. Leverton. In AGARD Aerodyn. of Rotary Wings. Feb. 1973. 14 p. refs. (For availability see N73-21031 12-02)

A 2-bladed 56-ft diameter rotor was run on a tower in an inverted mode so that the problem of recirculation and the difficulties of measuring noise directivity characteristics could be overcome. This paper outlines the analysis procedure used and presents the detailed results obtained. From a practical point of view rotor noise can be considered to consist of rotational or

discrete frequency noise, low frequency broadband noise and high frequency broadband noise. The spectrum characteristics and the directivity patterns of each of these sources have been examined as a function of the blade tip speed, the total rotor thrust and the measurement angle relative to the rotor disc plane. The trends associated with the overall noise, which is dependent on the relative magnitude of the individual sources, have also been studied. These results have been compared, where possible, with the trends given by theoretical and semiempirical prediction methods. Time history traces are also included; these show that even under ideal conditions rotor noise is impulsive in nature. Author

**N73-21920\*** Advisory Group for Aerospace Research and Development, Paris (France)  
**HELICOPTER BLADE FLUTTER. Revision of Part 3, Chapter 10 of AGARD Manual on Aeroelasticity**

N. D. Ham (MIT, Cambridge). Jan. 1973. 37 p. refs. (AGARD-R-607). Avail. NTIS HC \$4.00

Methods of analysis of helicopter blade flutter for both hinged and hingeless blades are presented. The major types considered are bending-torsion flutter, flap-lag flutter, and stall flutter. Both hover and forward flight are considered. Means of avoiding flutter are described. Author

**N73-21931#** Advisory Group for Aerospace Research and Development, Paris (France)  
**AERODYNAMICS OF ROTARY WINGS**

Norman D. Ham (MIT). Mar. 1973. 9 p. refs. Presented at Fluid Dyn. Panel Specialists Meeting, Marseille, 13-15 Sep. 1972. (AGARD-AR-61, AGARD-CP-111). Avail. NTIS HC \$3.00

The proceedings of a conference to discuss the aerodynamics of rotary wings are presented. The subjects discussed are: (1) rotor wakes, (2) rotors at hover and at high advance ratio, (3) rotor unsteady airloads, (4) rotor airfoils, (5) rotor configurations, and (6) noise generated by rotary wings. P.H.F.

**N73-24042#** Advisory Group for Aerospace Research and Development, Paris (France)  
**AIRCRAFT PERFORMANCE: PREDICTION METHODS AND OPTIMIZATION**

J. Williams, ed. Mar. 1973. 345 p. refs. In ENGLISH and partly in FRENCH. (AGARD-LS-56). Avail. NTIS HC \$19.25

The development and application of aircraft performance prediction methods are developed. The methods are applied to subsonic and supersonic aircraft. The basic topics discussed include: (1) range and radius capabilities, (2) takeoff and landing operations, and (3) aircraft maneuvers. Problems of aerodynamic prediction, aircraft mass estimation, and engine selection are included. Parametric and optimization techniques for aircraft design synthesis are reported. For individual titles, see N73-24043 through N73-24054.

**N73-24043** Ministry of Defence, London (England). Project Performance Analysis Section  
**RANGE AND RADIUS OF ACTION PERFORMANCE PREDICTION FOR TRANSPORT AND COMBAT AIRCRAFT**

Robert K. Page. In AGARD Aircraft Performance Prediction Methods and Optimization. Mar. 1973. 32 p. refs. (For availability see N73-24042 15-02)

Numerical methods for determining the range and radius of action performance of transport and combat aircraft are presented. The data required for the prediction process are explained. Conditions which govern the choice of method to be used are analyzed. The following parameters are examined to show the effect on aircraft range: (1) optimum cruising speeds, (2) cruise height schedules and integrated range, (3) effect of various aircraft and engine characteristics. Mathematical models are included to support the theoretical concepts and tables of data are provided to show application of data. Author

**N73-24044** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

**AIRFIELD PERFORMANCE PREDICTION METHODS FOR TRANSPORT AND COMBAT AIRCRAFT**

John Williams *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 56 p refs (For availability see N73-24042 15-02)

Methods for evaluating and predicting the airfield performance of turbojet and turbofan aircraft operating in conventional and short takeoff modes are developed. Airfield performance parameters include: (1) accelerating and decelerating ground run, (2) rotation to liftoff and from touchdown, (3) airborne flare, up and out, and (4) climb and descent approach. The aircraft configurations to which the data apply are described. The factors involved in airfield performance prediction are formulated separately for takeoff and landing operations. The sensitivity of airfield performance comparisons to the specific choice of technical and operational assumptions is illustrated. Author

**N73-24045** Dornier-Werke GmbH, Friedrichshafen (West Germany). Flight Mechanics Dept.

**FLIGHT MANOEUVRE AND CLIMB PERFORMANCE PREDICTION**

Herbert Friedel *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 51 p refs (For availability see N73-24042 15-02)

Methods for predicting aircraft flight maneuver and climb performance are presented. The methods are based on the equations of motion in a vertical and in a horizontal plane. The problems concerning the point performance values are explained. The relationship between excess power and load factor and their influence on climb and turn performance are discussed. Methods for evaluating the Mach-dependent performance values and the related optimum values are reported. Author

**N73-24046** Service Technique Aeronautique, Paris (France).

**THE ESTIMATION OF AERODYNAMIC COEFFICIENTS NECESSARY FOR PERFORMANCE CALCULATIONS**

C. Luevans *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 28 p *In* FRENCH (For availability see N73-24042 15-02)

Aerodynamic coefficients are used to study the performance of scale and wind tunnel models of transport aircraft. Data cover fuselage reactions, boundary layer evolution, and differences in results for the two models. Particular attention was given to the effects of boundary layer flow separation, boundary layer evolution, boundary layer reaction near flight and attack edge, and shock wave interaction with the boundary layer.

Transl. by E.H.W.

**N73-24047** Service Technique Aeronautique, Paris (France).

**AIRCRAFT MASS**

C. Vvler and P. Cormier *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 21 p *In* FRENCH (For availability see N73-24042 15-02)

A study was made of methods used to estimate aircraft mass and the effects of that mass on the aircraft performance.

Transl. by E.H.W.

**N73-24048** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**ENGINE SELECTION FOR TRANSPORT AND COMBAT AIRCRAFT**

James F. Dugan, Jr. *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 55 p refs (For availability see N73-24042 15-02)

CSCL 21A

The procedures for selecting engines for transport and combat aircraft during the design process are presented. The types of aircraft considered are: (1) a long haul conventional takeoff and landing transport, (2) a short haul vertical takeoff and landing transport, (3) a long range supersonic transport, and (4) a fighter aircraft. The influence of aircraft noise considerations on engine selection is examined. The aerodynamic characteristics of supercritical wings and their effect on engine selection are reported. Author

**N73-24049** Boeing Co., Seattle, Wash. Commercial Airplane Div.

**PARAMETRIC AND OPTIMISATION TECHNIQUES FOR AIRPLANE DESIGN SYNTHESIS**

Richard E. Wallace *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 57 p refs (For availability see N73-24042 15-02)

Aircraft design synthesis for various conditions of performance and load carrying capacity is discussed. The subjects presented are: (1) parametric evaluation techniques, (2) optimization evaluation techniques, and (3) computerized airplane design synthesis. Charts are developed to show the elements of synthesis, principal lines of data flow for aircraft design, propulsion parameters, aerodynamic parameters, and optimization methods.

Author

**N73-24050** Societe Nationale Industrielle Aerospatiale, Paris (France).

**DISCREPANCY BETWEEN APPROVAL AND MODERNISM**

G. Dumas *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 3 p (For availability see N73-24042 15-02)

The characteristics of aircraft flight manuals and their formats for presentation of information are discussed. A specific example of the take-off performance chart is developed. Discrepancies in performance data which arise from different methods of compiling and computing the information are cited. A diagram of a typical takeoff chart to show the interrelationships of outside air temperature, flap setting, aircraft weight, speed ratio, runway slope, and wind velocity and their effect on takeoff distance is included. Author

**N73-24051** Technische Hogeschool, Delft (Netherlands).

**AN ANALYTICAL EXPRESSION FOR THE BALANCED FIELD LENGTH**

E. Torenbeek *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 8 p refs (For availability see N73-24042 15-02)

A tractable analytical expression for the balanced field length of a civil aircraft to be used in parametric design studies is presented. It is demonstrated that in the project design stage, a detailed solution of the equations of motion and the graphical-numerical processes for the definition of the decision point can be avoided without serious loss of accuracy. Mathematical models are prepared to show the method for analyzing aircraft takeoff performance. Diagrams are included to show the phases of takeoff which influence the aircraft performance and forces exerted on the aircraft during the takeoff phases. Author

**N73-24052** Dornier-Werke GmbH, Friedrichshafen (West Germany).

**SUPPLEMENTARY NOTE TO FLIGHT MANOEUVRE AND CLIMB PERFORMANCE PREDICTION**

P. Foerster *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 8 p (For availability see N73-24042 15-02)

A numerical analysis of the minimum time climbing procedure for aircraft is presented. The procedure is defined as the locus of all tangent points of the constant energy lines and the constant specific excess power lines on the performance chart. In a similar manner, the minimum fuel climbing procedure is defined by a locus of all tangent points of the constant energy maneuverability index line and the constant specific energy lines. Specific application of the methods to a typical subsonic aircraft is analyzed. Author

**N73-24053** Hawker Siddley Aviation Ltd, Brough (England).

**MINIMUM TIME TRAJECTORY COMPUTATION DEVELOPMENT OF THE SALAKRISHNAN METHOD**

P. Middleton *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 6 p ref (For availability see N73-24042 15-02)

The development of a computer program for determining minimum time trajectory for aircraft flight is discussed. In the method discussed, the state and control variables are considered at a number of discrete points and a path through the matrix of these values is computed for the solution. The gradient method

of computation in which the equations of motion are integrated at each iteration is described. Mathematical models and graphs are included to support the theoretical considerations. Author

**N73-24064** Royal Aircraft Establishment, Farnborough (England)  
**REVIEW OF TWO METHODS OF OPTIMIZING AIRCRAFT DESIGN**

D. L. Kirkpatrick. In AGARD Aircraft Performance Prediction Methods and Optimization. Mar 1973. p 14. (For availability see N73-24042 15-02)

Two methods of optimizing aircraft design are discussed. One is an analytical method of optimizing three of the principal design variables of a subsonic swept wing jet transport aircraft and demonstrated how optimum design is affected by changes in mission requirements, operational constraints, and assumed design changes. The other method uses an aircraft design program coupled with the multivariate analysis technique to optimize 15 aircraft design variables using equations to represent the aerodynamic characteristics of the wing and high-lift devices, the masses of all the various aircraft components, and the engine performance. Author

**N73-27000#** Advisory Group for Aerospace Research and Development, Paris (France)  
**MILITARY APPLICATIONS OF V/STOL AIRCRAFT, VOLUME 1**

Apr 1973. 145 p. refs. Partly in ENGLISH and partly in FRENCH. Presented at 41st meeting of the flight Mech. Panel of AGARD, Brussels, 23-25 Oct 1972. (AGARD-CP-126-Vol.1) Avail NTIS HC \$9.25

The proceedings of a conference on the military applications of V/STOL aircraft are presented. Past developments on experimental V/STOL aircraft as well as current military doctrine and operational experience are discussed. Ongoing and new development programs are reviewed to provide visibility to potential new capabilities. Future military applications for V/STOL aircraft in terms of currently perceived operational requirements were analyzed. For individual titles, see N73-27001 through N73-27013.

**N73-27001** Massachusetts Inst. of Tech., Cambridge  
**A REVIEW OF PAST AGARD/NATO ACTIONS ON V/STOL AIRCRAFT AND THEIR APPLICATIONS**

R. H. Miller. In AGARD Mil Appl of V/STOL Aircraft, Vol. 1. Apr 1973. 3 p. (For availability see N73-27000 18-02)

The 1969 meeting was convened in order to review the results of an AGARD study, V/STOL Comparison Study, conducted by an ad hoc group of specialists in late 1968 and 1969 and published as AGARD Advisory Report No. 18. This study reviewed the status of existing technology, giving details of the many VTOL vehicles which had been built and the lessons learned from their flight experiences. The report then reviewed the manner in which further research could be expected to increase the effectiveness of such vehicles and the potential mission improvements which would result. The missions considered were attack, transport and rescue. Finally a research program was outlined which hopefully would ensure achieving these improvements. Author

**N73-27002** Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France)  
**WIND TUNNEL FOCUSING POINT STUDY AND FLIGHT TEST OF ASSULT MIRAGE 3 5 [ETUDE ET MISE AU POINT EN SOUFFLERIE ET EN VOL DE L'AVION DASSAULT MIRAGE 3 5]**

G. DeRichemont. In AGARD Mil Appl of V/STOL Aircraft, Vol. 1. Apr 1973. 15 p. In FRENCH. (For availability see N73-27000 18-02)

Flight transition and control problems of the Mirage 3 (5) attack aircraft are studied during flight and in wind tunnels. Data cover flight variations caused by exhaust, longitudinal skidding effects, and lift. A comparison was made of test results. Transl by E. H. W.

**N73-27003** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Prototype Div.

**A REVIEW OF THE US TRI-SERVICE V/STOL PROGRAMS**  
Bernard Lindenbaum and Daniel E. Fraga. In AGARD Mil Appl of V/STOL Aircraft, Vol. 1. Apr 1973. 17 p. refs. (For availability see N73-27000 18-02)

A brief history of the US Tri-Service V/STOL Programs is presented and aspects of propeller-based propulsion systems for VTOL aircraft as represented by the three distinctly different design concepts found in the XC-142A, X-19 and X-22A are examined. A comparison of the basic characteristics of these aircraft is provided in hover and vertical flight, transition and STOL flight and flight in the conventional mode. This includes a discussion of vehicle performance and efficiencies, handling qualities, and method of flight control. In addition a summary of the major accidents associated with these programs is presented as well as a brief discussion of the impact of technology improvements on future propeller driven VTOL designs. Author

**N73-27004** Dornier-Werke GmbH, Friedrichshafen (West Germany)

**DO 31 EXPERIMENTAL PROGRAM: RESULTS AND CONCLUSIONS OBTAINED AND FUTURE OUTLOOK [PROGRAMME EXPERIMENTAL DO 31: RESULTATS OBTENUS ET CONCLUSIONS A TIRER POUR L'AVENIR]**  
Radoslaw Draganow and Heinz Max. In AGARD Mil Appl of V/STOL Aircraft, Vol. 1. Apr 1973. 15 p. refs. In FRENCH. (For availability see N73-27000 18-02)

The technical aspects of the Dornier 31 V/STOL aircraft and the research project leading to production of the aircraft are discussed. The following problems of V/STOL aircraft operation are discussed: (1) control of the engine system, (2) stability and control in hover and transition, (3) jet interference effects, (4) recirculation and ground erosion effects, and (5) noise problems. Author

**N73-27005** Marine Aircraft Wing (2d), Cherry Point, NC  
**AV-8A HARRIER CONCEPT AND OPERATIONAL PERFORMANCE, US MARINE CORPS**

T. H. Miller, Jr. and C. M. Baker. (Marine Aircraft Group 32, Beaufort, S. C.) In AGARD Mil Appl of V/STOL Aircraft, Vol. 1. Apr 1973. 6 p. (For availability see N73-27000 18-02)

The design concept and operational performance of the AV-8A Harrier aircraft are discussed. An analysis of the US Marine Corps requirements and employment of the aircraft for military purposes is presented. The use of V/STOL aircraft in various military situations is reported. Author

**N73-27006** Vereinigte Flugtechnische Werke GmbH, Bremen (West Germany)

**VAK 191 B EXPERIMENTAL PROGRAM FOR A V/STOL STRIKE-RECCE AIRCRAFT**

Rolf Riccius and Werner Sobotta. In AGARD Mil Appl of V/STOL Aircraft, Vol. 1. Apr 1973. 18 p. refs. (For availability see N73-27000 18-02)

The design, development, and flight characteristics of the VAK 191b strike/reconnaissance aircraft are presented. The subjects discussed are: (1) research and development test program, (2) control systems, (3) longitudinal response, (4) hovering and vertical flight path characteristics, (5) flight control system transition characteristics, and (6) growth potential. Author

**N73-27007** Canadair, Ltd., Montreal (Quebec)  
**TESTING AND EVALUATION OF THE CANADAIR CL-84 TILT WING V/STOL AIRCRAFT**

F. C. Phillips. In AGARD Mil Appl of V/STOL Aircraft, Vol. 1. Apr 1973. 13 p. refs. (For availability see N73-27000 18-02) Avail NTIS

The testing and evaluation of the CL-84 tilt wing V/STOL aircraft are discussed. The subjects presented are: (1) the CL-84 prototype program, (2) evaluation program, (3) operational experience, (4) application to specific military roles, and (5) instrument flying evaluation. Author

**N73-27008** Avions Marcel Dassault, Saint-Cloud (France)  
**EXPERIENCE ACQUIRED DURING THE COURSE OF**

**FLIGHT TESTS AND OPERATIONAL UTILIZATION OF BREGUET 941 STOL AIRCRAFT [EXPERIENCE ACQUISE AU COURS DES ESSAIS EN VOL ET EN UTILISATION OPERATIONNELLE DE L'AVION STOL BREGUET 941]**

J. Cerny, Rhein. In AGARD Mil. Appl. of V/STOL Aircraft, Vol. 1, Apr 1973, 12 p. refs. In FRENCH (For availability see N73-27000 18-02)

The history and performance principles of the Breguet 941 STOL aircraft are presented. Problems encountered during the course of flight tests and solutions adopted are given. Test data cover handling qualities, operational characteristics, rolling stability on the ground, and flight qualities. Transl. by EHW

**N73-27008\*** National Aeronautics and Space Administration, Washington, D.C.

**NASA PROPULSIVE LIFT STOL TECHNOLOGY PROGRAM**

Gerald G. Kayten and William S. Aiken. In AGARD Mil. Appl. of V/STOL Aircraft, Vol. 1, Apr 1973, 4 p. (For availability see N73-27000 18-02)

CSCD 01C

A NASA propulsive-lift technology program for short takeoff aircraft is discussed in the propulsive-lift program, turbofan engine power is used to augment the lift of essentially conventional wings. Potentially important applications of the propulsive lift developments for various aircraft operating conditions are reported. It is stated that the objective of the program is to provide technical information on the design, development, operation, and regulation of propulsive-lift aircraft. Author

**N73-27010\*** De Havilland Aircraft Co., Ltd., Downsview (Ontario)

**THE BUFFALO/SPEY JET-STOL RESEARCH AIRCRAFT**

D. C. Whittley. In AGARD Mil. Appl. of V/STOL Aircraft, Vol. 1

Apr 1973, 13 p. refs. Sponsored in part by NASA (For availability see N73-27000 18-02)

CSCD 01C

The program to design and build a Buffalo/Spey Augmentor-Wing research aircraft is presented. The development of an internally blown flap system for the generation of powered lift is discussed. Modification, development and testing of the Rolls-Royce Spey engine are reported. The ground tests and first flights of the aircraft are described and the application of the internally blown flap concept for short takeoff military transport aircraft is proposed. Author

**N73-27011** British Aircraft Corp., Weybridge (England)

**MILITARY ASPECTS OF CIVIL V/STOL AIRCRAFT**

N. W. Boorer. In AGARD Mil. Appl. of V/STOL Aircraft, Vol. 1, Apr 1973, 12 p. ref. (For availability see N73-27000 18-02)

The rationale of developing a military tactical short takeoff transport aircraft in an evolutionary pattern in parallel with the development of civil short takeoff aircraft is presented. The main characteristics of military and civil short takeoff aircraft are described. The military requirements and operational considerations of the short takeoff transport aircraft are defined. Author

**N73-27012** Aeronautical Systems Div., Wright-Patterson AFB, Ohio

**SELECTING A STOL TRANSPORT**

Fred D. Orazio, Sr. In AGARD Mil. Appl. of V/STOL Aircraft, Vol. 1, Apr 1973, 9 p. refs. (For availability see N73-27000 18-02)

The procedures for identifying the proper characteristics of a short takeoff transport aircraft using current and past development efforts are discussed. The procedures include: (1) feasible designs incorporating powered/lift systems; (2) advanced systems (including composite structures); (3) high flotation landing gears; (4) vulnerability protection; (5) operating margins and criteria; (6) aircraft handling qualities; (7) operating constraints; and (8) costs. Author

**N73-27013** Bundesminister fuer Verteidigung, Bonn (West Germany)

**GERMAN COMMENTS ON FUTURE V/STOL REQUIREMENTS**

Uwe Koester. In AGARD Mil. Appl. of V/STOL Aircraft, Vol. 1

Apr 1973, 2 p. (For availability see N73-27000 18-02)

A survey of the V/STOL weapon system developments in Germany or with German participation is presented. The rationale for developing short takeoff rather than vertical takeoff aircraft is developed. Problems involved in the engineering of short takeoff aircraft are described. The reasons for not formulating concrete military requirements for short takeoff aircraft are enumerated. Author

**N73-27005#** Advisory Group for Aerospace Research and Development, Paris (France)

**INFLUENCE OF PILOT AND AIRCRAFT CHARACTERISTICS ON STRUCTURAL LOADS IN OPERATIONAL FLIGHT**

J. R. Sturgeon. May 1973, 28 p. refs.

(AGARD-R-508) Avail. NTIS HC \$3.50

Some aircraft handling problems met in operational conditions are described and compared with flight test conditions. It is concluded that errors in flight instrumentation and physiological cues have a substantial influence on control capability. A unified strategy for flight in all operational conditions is required to reduce these problems. A strategy, aimed at minimizing structural loads and aerodynamic problems in all flight conditions, is proposed that will restore to pilot and autopilot flying the positive stability in pitch and yaw which is a classic requirement for aircraft operating in the stick free mode. Proposals are made for improving the requirements of flight instruments to reduce control problems during complex maneuvers and flight in severe wind shear conditions. Author

**N73-27006#** Advisory Group for Aerospace Research and Development, Paris (France)

**V/STOL HANDLING-QUALITIES CRITERIA. PART 2: DOCUMENTATION**

Jun 1973, 88 p. refs.

(AGARD-R-577-Pt-2) Avail. NTIS HC \$6.50

The factors which affect the handling characteristics of V/STOL aircraft are discussed. The criteria are based on several sources of information to include: (1) analytical studies; (2) piloted simulator tests; (3) flight tests; and (4) specially equipped variable stability aircraft and helicopters. The results of the tests involving handling and stability are presented in tabular form. Author

**N73-31954#** Advisory Group for Aerospace Research and Development, Paris (France)

**ESCAPE MEASURES FOR COMBAT HELICOPTER CREWS**

Aug 1973, 39 p. refs.

(AGARD AR-62) Avail. NTIS HC \$4.00

A study was conducted to determine the requirements and characteristics of escape systems for use with helicopters. It was stated that escape systems are feasible but that the rotary wing creates the greatest obstacle to emergency seat ejection. It was recommended that helicopter escape concepts be considered under the following categories: (1) an escape system for retrofit into helicopters already in production or in service; (2) an escape system for a near term solution; and (3) an escape system for a far term solution. The conclusion of the study was that a retrofitable escape system is practical only if it requires an absolute minimum of development time and does not require major changes to the helicopter. The only likely candidates to satisfy the requirement are manual bailout or sideward ejection. Author

**N74-10908#** Advisory Group for Aerospace Research and Development, Paris (France)

**SPECIALISTS MEETING ON HELICOPTER ROTOR PREDICTION METHODS**

Aug 1973, 150 p. refs. Mostly in ENGLISH, partly in FRENCH. Conf. held at Milan, 30-31 Mar 1973.

(AGARD-CP-122, AGARD-CP-122) Avail. NTIS HC \$9.50

The proceedings of a conference on methods for predicting the dynamic loads on helicopter rotors are presented. The subjects discussed are: (1) rotary wing design technology, (2) rotor system evaluation using helicopter flight simulation program, (3) load prediction methods for hingeless rotor helicopters, and (4) integrated rotor/body loads prediction. For individual titles, see N74-10908 through N74-10918.

**N74-10909** Kaman Aerospace Corp. Bloomfield, Conn.

#### ROTARY WING DESIGN METHODOLOGY

Andrew Z. Lemnios. In AGARD Specialists Meeting on Helicopter Rotor Prediction Methods. Aug 1973. 14 p. refs. (For availability see N74-10908 02-02)

A nonlinear aeroelastic blade loads analysis is described for calculating the coupled responses, airloads distributions and performance of helicopter rotors. The analysis is divided into two major parts: (1) calculation of blade transient stability behavior by means of linearized, coupled equations of motion, (2) calculation of periodic blade dynamics and airloads distributions using fully coupled, nonlinear equations of motion. The analysis includes six response modes and two input control modes. The equations of motion include all nonlinear inertial coupling effects and nonlinear aerodynamic effects such as reverse flow, Mach number variations, large induced flow angles, unsteady aerodynamics, and variable inflow. Additional features to the analysis are the inclusion of feedback mechanical coupling among the assumed modes and the inclusion of springs and dampers for each mode. Author

**N74-10910** Boeing Co. Philadelphia, Pa. Structures Staff  
CURRENT LOADS TECHNOLOGY FOR HELICOPTER ROTORS

Richard Gabel. In AGARD Specialists Meeting on Helicopter Rotor Prediction Methods. Aug 1973. 11 p. refs. (For availability see N74-10908 02-02)

Prediction of fatigue design loads is essential for proper sizing of helicopter rotor systems. The C-60 rotor loads computer program is discussed. It incorporates the effects of airfoil section geometry, compressibility, stall, three dimensional flow, unsteady aerodynamics, and nonuniform inflow to provide reliable rotor loads for steady-state flight conditions even into the blade stall region. Rotor loads predictions are compared with actual flight test data from Boeing CH 47 and Model 347 helicopters. An approach to component sizing is presented in which a fatigue design loads histogram is constructed using calculated steady-state flight loads and empirically determined maneuver loads. Current efforts to improve rotor loads predictions through incorporation of fully coupled lag pitch-flap routines, simulation of control system dynamics and development of maneuver loads programs are discussed. Author

**N74-10911** Advisory Group for Aerospace Research and Development, Paris (France).

#### PREDICTION OF HELICOPTER ROTOR LOADS

J. Gallot. In its Specialists Meeting on Helicopter Rotor Prediction Methods. Aug 1973. 8 p. refs. In FRENCH. ENGLISH summary. (For availability see N74-10908 02-02)

The correct design of a rotor requires quite a precise knowledge of the alternating loads to which blade and hub are submitted. The problem of the stress evaluation, from the early design stage, may lead very sophisticated methods, because the blade is operating in a very complex environment. Nevertheless simplified methods may give sufficiently precise results to set up correctly the dimensions of the main elements of the rotor. The method described here supposes simple aerodynamics, independent of blade elastic deformations. The degree of simplification, achieved in this theoretical method seems to be justified by the correlation obtained with experimental airloads measured on a model rotor and stresses recorded on the same rotor or a full-scale semi-articulated rotor. Author

**N74-10912** United Aircraft Corp. Stratford, Conn. Sikorsky Aircraft Div.

#### HELICOPTER ROTOR LOADS PREDICTIONS

Peter J. Arcidiacono and Raymond G. Carlson. In AGARD

Specialists Meeting on Helicopter Rotor Prediction Methods. Aug 1973. 12 p. refs. (For availability see N74-10908 02-02)

A review is presented of the assumptions and techniques forming the basis for detailed computation of rotor loads. Typical correlation results showing the effects of variable inflow and unsteady aerodynamics on blade stresses and control loads are presented. These effects are shown generally to improve the accuracy of predicted results. A discussion of areas where further work can be expected to provide a stronger technical foundation for present analyses is presented. The principal areas include more detailed modeling of (1) the dynamic stall process, (to define unsteady drag, airfoil, and blade sweep effects), (2) blade lifting surface effects (to model more accurately blade-vortex interaction effects) and (3) airframe dynamics effects (to define more accurately the dynamic coupling between blade and hub motions). Author

**N74-10913** Bell Helicopter Co. Fort Worth, Tex.  
ROTOR SYSTEM DESIGN AND EVALUATION USING A GENERAL PURPOSE HELICOPTER FLIGHT SIMULATION PROGRAM

Richard L. Bennett. In AGARD Specialists Meeting on Helicopter Rotor Prediction Methods. Aug 1973. 15 p. refs. (For availability see N74-10908 02-02)

New helicopter rotor systems are designed and existing configurations are evaluated by means of a general purpose helicopter flight simulation computer program. Discussed in this paper are both the analysis incorporated in the program and examples of the results obtained from the program. The three major parts of the analysis are: (1) mathematical model of an elastic rotor based on the modal technique, (2) rotor aerodynamics, and (3) basic rigid vehicle flight mechanics. The interrelationship among these three parts are discussed. The program has been used in support of the following phases of rotor system design and evaluation: (1) rotor blade frequency placement, (2) wind tunnel simulation, (3) steady state flight simulation, and (4) transient or maneuvering flight simulation. Author

**N74-10914** Westland Helicopters, Ltd. Yeovil (England)  
THE PREDICTION OF LOADING ACTIONS ON HIGH SPEED SEMI-RIGID HELICOPTERS

K. T. McKenzie and D. A. S. Howell. In AGARD Specialists Meeting on Helicopter Rotor Prediction Methods. Aug 1973. 19 p. refs. (For availability see N74-10908 02-02)

The analytical techniques employed to predict the primary loading actions of a high speed semi-rigid rotor helicopter are described. The loading actions considered are overall aircraft trim balance, oscillatory rotor loading and vibratory forcing of the airframe. Some of the design considerations associated with each of these loading actions and the correlation with flight test analysis are presented. A description is given of a technique for the analysis of flight test results which has enabled a detailed comparison of the harmonic response of individual modes to be made. Author

**N74-10915** Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany)

#### LOADS PREDICTION METHODS FOR HINGELESS ROTOR HELICOPTERS

G. Reichert. In AGARD Specialists Meeting on Helicopter Rotor Prediction Methods. Aug 1972. 12 p. refs. (For availability see N74-10908 02-02)

The special loading condition of the hingeless rotor helicopter is discussed. For the prediction of the loads, the aeroelastic behaviour of the rotor blades including characteristic coupling effects has to be considered. To determine the properties of the hingeless rotor system in an analytical approach, a mathematical model can be used, which simulates the aerodynamic and dynamic behaviour adequately. There is good experience with an aerodynamically and dynamically equivalent system of an articulated

rotor with high hinge offset. Analytical data as well as flight test data will be shown for different flight conditions including maneuvers. There is relatively good correlation. The loads necessary for the structural design of the rotor can be predicted reasonably well. The methods are not satisfactory for control loads in stalled conditions and for high harmonic vibratory loads.

Author

N74-10816 Army Air Mobility Research and Development Lab., Moffett Field, Calif.

#### INTEGRATED ROTOR/BODY LOADS PREDICTION

R. M. Carlson and A. W. Kerr (Lockheed-Calif., Burbank) In AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1972 8 p refs (For availability see N74-10808 02-02)

An interdisciplinary analysis, which has grown out of a requirement for a nonlinear handling qualities evaluation tool, has been mechanized in a fashion which provides a capability to predict rotor loads affected by rotor/airframe interaction in steady-state and transient flight conditions. The modeling philosophy in developing this analysis combines the capabilities of a team of analysts from several specialties to create a versatile model which provides consistent data for numerous applications. This philosophy is presented in addition to a description of the model and a summary of its range of applications. Examples involving rotor loads prediction are presented: (1) evaluation of clearance between rotor blades and fuselage during extreme maneuvers, (2) estimation of four-bladed rotor reactionless impeller mode stability and loads, and (3) general maneuver capability and transient loads estimation. Also presented are areas proposed for continuing development and refinement of the model to further increase range of applications.

Author

N74-12713# Advisory Group for Aerospace Research and Development, Paris (France).

#### MARKINGS FOR PROPELLER CONSPICUITY

T. C. D. Whiteside (RAF Inst. of Aviation Med.) Sep. 1973 17 p refs

(AGARD-AR-66) Avail. NTIS HC \$3.00

The general problem of marking propellers so that they may be seen is discussed. The propeller must be conspicuous to persons walking near it when the aircraft is on the ground but, on the other hand, in taxiing and in flight it must not be distracting or annoying to the pilot. Other factors to be considered are the conspicuity at low and at high rpm; the conspicuity against various backgrounds since markings easily visible against a dark ground may not be visible against a light ground; the use of coloured markings which, although easily seen on a stationary propeller, become desaturated when the propeller is turning, and finally, the presence of brightness and of colour contrast with the background. In theory, to obtain maximal brightness contrast, black and white markings should be used so that the blades may be seen against either light and dark background. As black matt paint may appear grey since it scatters incident light, the markings should be in a gloss finish.

Author

N74-17720# Advisory Group for Aerospace Research and Development, Paris (France)

#### FLIGHT IN TURBULENCE

Nov 1973 365 p refs Presented at the 42d Meeting of the Flight Mech Panel of AGARD, Woburn Abbey, England, 14-17 May 1973

(AGARD-CP-140) Avail. NTIS HC \$21.25

The proceedings of a conference on the effects of atmospheric turbulence on aircraft operation are presented. The subjects discussed include the following: (1) characteristics of atmospheric turbulence, (2) aircraft operational problems created by atmospheric turbulence, (3) analysis of wake vortices and wind shear,

(4) structural loads and gust criteria, (5) aircraft design for performance under turbulent conditions, and (6) application of energy management concepts to flight path control in turbulence. For individual titles, see N74-17721 through N74-17746.

N74-17721 Meteorological Office, Bracknell (England).

#### TURBULENCE AT MEDIUM AND HIGH FLIGHT LEVELS

S. G. Comford In AGARD Flight in Turbulence Nov. 1973 14 p refs (For availability see N74-17720 09-02)

The characteristics of atmospheric turbulence at medium and high flight levels are discussed. Emphasis is placed on research on turbulence in clear air away from mountains and local storms and in clear air near storm tops. Estimates on the likelihood of encountering clouds and precipitation at the cruising levels of supersonic transport aircraft. Numerical forecasting techniques for atmospheric turbulence are reported.

Author

N74-17722\* National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

#### PROBLEMS IN THE SIMULATION OF ATMOSPHERIC BOUNDARY LAYER FLOWS

George H. Fichtl In AGARD Flight in Turbulence Nov. 1973 14 p refs (For availability see N74-17720 09-02)

The realistic simulation of flow in the atmospheric boundary layers at heights greater than two kilometers is discussed. Information concerning horizontally homogeneous and statistically stationary atmospheric boundary layer flows is presented. The problems related to the incorporation of the information into atmospheric wind simulation programs are analyzed. The information which the meteorologist must acquire in order to provide a basis for improving the simulation of atmospheric boundary flows is explained.

Author

N74-17723 National Aeronautical Establishment, Ottawa (Ontario) Flight Research Lab.

#### TURBULENCE AND MESOSCALE HORIZONTAL TEMPERATURE GRADIENTS IN THE LOWER STRATOSPHERE

Ian MacPherson In AGARD Flight in Turbulence Nov. 1973 15 p refs (For availability see N74-17720 09-02)

Data are presented on the frequencies of occurrence of turbulence and significant horizontal temperature gradients along with their dependence on altitude, season, underlying terrain, geographical location, and jet stream position. These factors are important both in the forecast problem and in the comparison of these results with those of other observing programs. Specific examples of encounters with atmospheric turbulence during the course of a research project on atmospheric instability are provided.

Author

N74-17724 Tennessee Univ. Space Inst., Tullahoma

#### REVIEW OF DATA AND PREDICTION TECHNIQUES FOR WIND PROFILES AROUND MANMADE SURFACE OBSTRUCTIONS

Walter Frost In AGARD Flight in Turbulence Nov. 1973 18 p refs (For availability see N74-17720 09-02)

(Contract NAS8-27387)

A review of experimental data and analytical models related to flow over bluff obstacles is presented to provide a survey of basic flow theory available to analyze atmospheric wind patterns and man-made surface obstructions. Primary emphasis is placed on the distortion of shear flows approaching and passing over buildings or bluff surfaces such as fences or steps. The various physical phenomena of pressure and velocity variation in the

separated flow regions surrounding the body, velocity profiles in the displaced flow over the body, and the origin and decay of induced turbulence along the boundaries of the separated regions are described. Author

**N74-17725** Delft Univ. of Technology (Netherlands) Dept. of Aeronautical Engineering.

**PROGRESS IN THE MATHEMATICAL MODELLING OF FLIGHT IN TURBULENCE**

O. H. Gerlach, G. A. J. VandeMoesdijk, and J. C. VanderVaart. *In AGARD Flight in Turbulence* Nov. 1973 38 p refs (For availability see N74-17720 09-02)

Problems of mathematical modelling of aircraft flight in turbulence are discussed. The simulation of flight in the lower atmosphere during the approach and landing portions of the flight are emphasized. The discrepancy between the usual Gaussian representation of atmospheric turbulence and the actual non-Gaussian atmosphere is analyzed. A parameter is introduced to characterize the actual turbulence sensed by the pilot. A method is presented for finding the range of altitudes at which the most significant disturbances are encountered during the approach.

Author

**N74-17726** British Overseas Airways Corp., London (England). **BOAC EXPERIENCE WITH TURBULENCE**

Ernest Chambers. *In AGARD Flight in Turbulence* Nov. 1973 13 p (For availability see N74-17720 09-02)

The effectiveness of airborne radar in giving adequate warning of convective turbulence in clouds is discussed. Some encounters with turbulence in clear air are described and matters relating to the forecasting, reporting, and dissemination of turbulence occurrence are presented. The development of an airborne clear air turbulence detector is recommended and the performance requirements of the detector are developed. Problems with low level wind shear are also examined. Author

**N74-17727** Deutsche Lufthansa Aktiengesellschaft, Frankfurt am Main (West Germany). Meteorological Dept.

**AN AIRLINE'S EXPERIENCE ON TURBULENCE**

Hans Dreyling. *In AGARD Flight in Turbulence* Nov. 1973 7 p (For availability see N74-17720 09-02)

A compilation of the replies of airline pilots to a questionnaire on different areas concerned with atmospheric turbulence is presented. An assessment is made on flight times in turbulence, strength and type of turbulence, and the potential effect of turbulence on airline operations. Specific geographical areas as well as airports with specific turbulence encounters are listed, and potential energy sources are mentioned. The turbulence penetration speed is discussed as well as means to avoid turbulent encounters or to alleviate turbulent conditions through air traffic control, meteorological reports, or pilot experience. Author

**N74-17728** Royal Aircraft Establishment, Farnborough (England).

**INFLUENCE OF PILOT AND AIRCRAFT CHARACTERISTICS ON STRUCTURAL LOADS IN OPERATIONAL FLIGHT**

J. R. Sturgeon. *In AGARD Flight in Turbulence* Nov. 1973 24 p refs. Presented at the 35th Meeting of the Struct. and Mater. Panel, Toulouse, France, 24-29 Sep. 1972 (For availability see N74-17720 09-02) (AGARD-608)

Some aircraft handling problems met in operational conditions are described and compared with flight test conditions. It is concluded that errors in flight instrumentation and physiological cues have a substantial influence on control capability. A procedure for minimizing structural loads and aerodynamic problems in all flight conditions is proposed. The procedure will restore to the pilot and to the autopilot controlled flying the positive stability in pitch and yaw which is required for aircraft operating in the stick free mode. Proposals are made for improving the requirements of flight instruments to reduce control problems during complex maneuvers and flight in severe wind shear conditions. Author

**N74-17729** British Aircraft Corp., Watton (England). Military Aircraft Div.

**AIRCRAFT RESPONSE TO TURBULENCE-CREW COMFORT**

**ASSESSMENTS USING POWER SPECTRAL DENSITY METHODS**

Brian Young. *In AGARD Flight in Turbulence* Nov. 1973 9 p refs (For availability see N74-17720 09-02)

The effects of atmospheric turbulence on the efficiency of a flight crew are analyzed. The factors are identified as (1) atmospheric turbulence levels, (2) the characteristics of the aircraft in responding to turbulence, including the effects of structural modes, and (3) the tolerance of the crew to the level and duration of vibration at the crew station. The use of power spectral density techniques for assessing crew ride comfort is explained. In addition to defining aircraft response in both vertical and lateral turbulence, it is possible to include the effects of structural modes, assess the effects of autostabilization, and include crew proficiency degradation as a parameter in operational studies. Author

**N74-17730** Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).

**THE EFFECT OF GUSTS AND WIND SHEAR FOR AUTOMATIC STOL APPROACH AND LANDING**

Gunther Schaefer. *In AGARD Flight in Turbulence* Nov. 1973 11 p refs (For availability see N74-17720 09-02)

The characteristics of a flight control system for short takeoff aircraft are discussed. The system is used during steep and curved approaches. The system was simulated and flight tested during more than 500 automatic STOL approaches and landings. The effects of gusts and wind shear, especially at extremely low indicated airspeeds during approach and flare, with respect to the pilot's workloads, passenger comfort, throttle activity, angle of attack measurement, and precision in approach and landing are analyzed. Author

**N74-17731** Transportation Systems Center, Cambridge, Mass.

**THE DETECTION OF AIRCRAFT WAKE VORTICES**

Ralph D. Kodis. *In AGARD Flight in Turbulence* Nov. 1973 9 p refs (For availability see N74-17720 09-02)

The hazards created by the trailing vortices deposited in the wakes of heavy jet aircraft are discussed. In the terminal area this hazard leads to longer separation standards and reduced runway capacity. In order to shorten the required separations without compromising safety it is necessary to be able to detect the presence and motion of vortices in regions where they constitute a threat. The sensing techniques that have been developed are reported. The characteristics of acoustic and wind pressure sensors for detecting vortices are described. Author

**N74-17732** Federal Aviation Administration, Washington, D.C. Office of Systems Engineering Management.

**WAKE VORTEX AVOIDANCE SYSTEM PROGRAM (WVAS)**

Lawrence Langweil. *In AGARD Flight in Turbulence* Nov. 1973 9 p refs (For availability see N74-17720 09-02)

A wake vortex avoidance system (WVAS) program is described. The objective of the program is to design and implement a ground based monitoring and predictive system at airports which will increase runway capacity by eliminating the need for larger separations between aircraft for safety from wake vortices. The program consists of three major tasks: (1) sensor development, (2) vortex behavior characterization and hazard definition, and (3) integration of these tasks into an overall system design. The meteorological factors which affect the performance of the proposed system are analyzed. Author

**N74-17733\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**VORTEX WAKE RESEARCH**

John A. Zalovick and H. Earl Dunham, Jr. *In AGARD Flight in Turbulence* Nov. 1973 14 p refs (For availability see N74-17720 09-02)

NASA investigations of aircraft trailing vortices are reviewed. Results obtained in flight on vortex characteristics, such as decay of maximum velocity and vortex drift, are presented for distances behind a generating C-5 aircraft from 0.6 to 13.0 nautical miles. The lateral control activity of a CV-990 aircraft probing the vortices generated by the C-5 aircraft is illustrated and the effect of the C-5 aircraft configuration on this activity is indicated. Results are presented from near-field and far-field studies of accelerated

vortex dissipation through the use of various devices such as mass ejection, spoilers, vortex generators, and trailing drag devices. Author

**N74-17734** Aeronautical Research Associates of Princeton, Inc., N.J.

**ON TURBULENCE ENVIRONMENT AND DESIGN CRITERIA**

John C. Houbolt. In AGARD Flight in Turbulence. Nov. 1973. 15 p. refs (For availability see N74-17720 09-02)

Aircraft design criteria based on the effects of atmospheric turbulence are discussed. Emphasis is placed on the power spectral techniques, but equivalences to the discrete-gust procedure are shown. Consideration is given to large design loads, such as limit load and to repeated loads which affect structural fatigue. Mathematical models are provided to illustrate the gust design approaches and the basic spectral procedure. Author

**N74-17735** NATO MRCA Development and Production Management Agency, Munich (West Germany)

**DESIGN PROBLEMS OF MILITARY AIRCRAFT AS AFFECTED BY TURBULENCE**

M. Hacklinger. In AGARD Flight in Turbulence. Nov. 1973. 9 p. ref (For availability see N74-17720 09-02)

The influence of atmospheric turbulence on the design of military aircraft is analyzed. The subject is treated in two main categories: (1) turbulence as a sizing factor in itself which determines static and fatigue strength of major parts of low load factor aircraft and (2) turbulence as an important design parameter of high load factor aircraft where stability of the augmented aircraft in manual or automatic terrain following flight, pilot proficiency under vibration, and the attitude accuracy of the aircraft as a weapons platform become important. The problem of designing for proper flight qualities in high speed tactical fighter missions is described with emphasis on analytical prediction of pilot task proficiency under the vibration environment created by airframe and flight control system characteristics. Author

**N74-17736** Messerschmitt-Boelkow GmbH, Ottobrunn (West Germany)

**INFLUENCE OF TURBULENCE ON HELICOPTER DESIGN AND OPERATION**

G. Reichert and M. Rade. In AGARD Flight in Turbulence. Nov. 1973. 16 p. refs (For availability see N74-17720 09-02)

The sensitivity of the helicopter to atmospheric turbulence because of the relatively low disc loading is discussed. The influences of other parameters such as rotor stiffness and damping are analyzed. The effects of these influences on different helicopters are compared. The main design problems of meeting operational and certification requirements and methods for improving the performance of helicopters are examined. Author

**N74-17737** De Havilland Aircraft Co., Ltd., Downsview (Ontario)

**DATA REQUIREMENTS ON TURBULENCE IN THE EARTH'S ATMOSPHERIC SHEAR LAYER FOR STOL DESIGN CRITERIA**

J. J. Glaser. In AGARD Flight in Turbulence. Nov. 1973. 8 p. refs (For availability see N74-17720 09-02)

The factors which affect the airworthiness of short takeoff aircraft, especially during the landing and takeoff phase of the operation. Atmospheric turbulence is one of the most important factors affecting aircraft behavior at low altitudes, and its description in terms of a realistic model is an essential step in the design, certification, and operation of STOL aircraft. A study to devise a low altitude gust model and to determine the relative importance of the gust model parameters of the responses of typical STOL aircraft was conducted. The significant features of the DHC-3 aircraft which was used in the test are analyzed. Author

**N74-17738** Hawker Siddeley Aviation Ltd., Hatfield (England)

**EXPERIENCE WITH A LOW ALTITUDE TURBULENCE MODEL FOR AUTOLAND CERTIFICATION**

R. M. P. McManus. In AGARD Flight in Turbulence. Nov.

1973. 8 p. ref (For availability see N74-17720 09-02)

The effects of atmospheric turbulence on the autoland system of the Trident aircraft are discussed. The aircraft was instrumented to obtain three axis gust time histories for each landing made. From these time histories a gust model was built up and was used for the initial certification of the automatic landing system. The results obtained with the gust model are compared with the statistical analysis of flight test data to determine the degree of correlation. Author

**N74-17739** British Aircraft Corp., Waybridge (England)

**STRUCTURAL LOADS AND GUST CRITERIA**

D. O. N. James. In AGARD Flight in Turbulence. Nov. 1973. 13 p. refs (For availability see N74-17720 09-02)

The effects of atmospheric turbulence on aircraft design criteria are analyzed. The discrete gust methods are compared with the power spectral density methods to determine the degree of application to aircraft gust load problems. The application of continuous turbulence design procedure was investigated. Mission analysis results are shown to be very sensitive to the assumed operating technique. Graphs of specific aircraft design envelope limit loads against the discrete gust load limit are provided. Author

**N74-17740** Royal Netherlands Aircraft Factories Fokker, Amsterdam

**RATIONAL CALCULATION OF DESIGN GUST LOADS IN RELATION TO PRESENT AND PROPOSED AIRWORTHINESS REQUIREMENTS**

J. YH. In AGARD Flight in Turbulence. Nov. 1973. 11 p. refs (For availability see N74-17720 09-02)

An analysis of accurately calculated gust loads for three short haul aircraft was conducted. The results are applied to the following conditions: (1) comparison of power spectral density and discrete gust methods, (2) comparison of power spectral density mission analysis and design envelope results, (3) comparison of power spectral density results for vertical and lateral gusts, and (4) a study of the specific problems of T-tail configurations. Graphs of load conditions for various aircraft components are provided. Author

**N74-17741** British Aircraft Corp., Warton (England) Military Aircraft Div.

**C.S.A.S. DESIGN FOR GOOD HANDLING IN TURBULENCE**

A. G. Barnes. In AGARD Flight in Turbulence. Nov. 1973. 14 p. refs (For availability see N74-17720 09-02)

The design objectives for aircraft control and stability augmentation systems are discussed with respect to the effects of atmospheric turbulence. The subjects presented include the following: (1) handling qualities requirements for flight in turbulence, (2) performance of unaugmented aircraft in turbulence, (3) performance of augmented aircraft in turbulence, and (4) approaches to stability augmentation systems development. Specific emphasis is placed on the aircraft parameters of planform, excitation derivatives, control power and aircraft size. Author

**N74-17742\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**THEORETICAL HORIZONTAL TAIL LOADS AND ASSOCIATED AIRCRAFT RESPONSES OF AN AUTOPILOT-CONTROLLED JET TRANSPORT FLYING IN TURBULENCE**

Boyd Perry, III and Kermit G. Pratt. In AGARD Flight in Turbulence. Nov. 1973. 9 p. refs (For availability see N74-17720 09-02)

An exploratory analytical study was conducted to analyze problem areas associated with a rigid aircraft controlled by a simple autopilot. The aircraft motion is constrained to the longitudinal phugoid and short period modes. The autopilot characteristics are described. The analytical procedure is explained and stabilizer loads together with some aircraft motions as functions of autopilot gains within the stability boundaries are determined. The effects of center of gravity location and altitude are considered. Author



**N74-17743** Royal Aircraft Establishment, Farnborough (England)  
Avionics Dept.

**THE DESIGN OF AUTOMATIC FLIGHT CONTROL SYSTEMS TO REDUCE THE EFFECTS OF ATMOSPHERIC DISTURBANCES**

M. J. Corbin and K. F. Goddard. In AGARD Flight in Turbulence Nov. 1973. 16 p. refs. (For availability see N74-17720 09-02)

The design of two experimental automatic flight control systems for the BAC 111 aircraft is described. One system used throttle and elevator controls and the other uses, in addition, direct lift control by means of spoilers. The landing performance of the systems is compared with conventional automatic landing systems. It is stated that discrete gusts experienced at heights below 15 meters can produce large touchdown errors exceeding the capability of the autopilot control. Author

**N74-17747** Establishment, Bedford (England)

Aero F

APPLI

FL

J

1

**MANAGEMENT CONCEPTS TO REDUCE THE EFFECTS OF TURBULENCE**

Flight in Turbulence Nov. 1973

74-17720 09-02)

The design of two experimental automatic flight control systems for the BAC 111 aircraft is described. One system used throttle and elevator controls and the other uses, in addition, direct lift control by means of spoilers. The landing performance of the systems is compared with conventional automatic landing systems. It is stated that discrete gusts experienced at heights below 15 meters can produce large touchdown errors exceeding the capability of the autopilot control. Author

**N74-17745** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**A NEW APPROACH TO GUST ALLEVIATION OF A FLEXIBLE AIRCRAFT USING AN OPEN LOOP DEVICE**

Pierre-Marie Hutin. In AGARD Flight in Turbulence Nov. 1973. 9 p. ref. In FRENCH. ENGLISH Summary. (For availability see N74-17720 09-02)

The application of optimization techniques for the purpose of gust alleviation is discussed. The basic approach is an extension of the Wiener's optimization theory to two control parameters and the application to the Caravelle aircraft. A comparison is made between the theoretical responses to a Gaussian stationary excitation and the responses to actual records of turbulence given by an analog computer taking into account the nonlinearities due to limited efficiency of the controls. Author

**N74-17746** Royal Aircraft Establishment, Bedford (England)  
**SOME COMMENTS ON METHODS OF AVOIDING THE EFFECTS OF TURBULENCE**

A. McPherson. In AGARD Flight in Turbulence Nov. 1973. 11 p. refs. (For availability see N74-17720 09-02)

The characteristics of airborne detectors for warning of the presence of clear air turbulence are discussed. The turbulence problem and the effects of atmospheric turbulence on aircraft performance are analyzed. The specific applications of infrared radiometer and Doppler lidar techniques are explained. Author

**N74-19652#** Advisory Group for Aerospace Research and Development, Paris (France)

**DESIGN AGAINST FATIGUE**

Dec. 1973. 122 p. refs. Presented at the 37th Meeting of the Structures and Mater. Panel at the Hague, Netherlands, 7-12 Oct. 1973.

(AGARD-CP-141) Avail. NTIS HC \$9.25

Papers presented at the conference on designing aircraft against fatigue are reported. Fatigue analysis and tests for fighter aircraft are emphasized. For individual titles, see N74-19653 through N74-19660.

**N74-19653** British Aircraft Corp., Preston (England)  
**SOME CONSIDERATIONS OF THE INFLUENCE OF FATIGUE IN THE DESIGN OF STRIKE AIRCRAFT**

A. N. Rhodes. In AGARD Design Against Fatigue Dec. 1973. 17 p. (For availability see N74-19652 11-02)

After summarizing some of the factors which characterize strike aircraft with regard to their fatigue design, the types of external loading to which it will be subjected in service are considered. A consideration is also given to some of the factors which influence the choice of materials, aircraft layout and design. Qualification of the finished product is discussed, as are some of the techniques in monitoring service usage. Problem areas are highlighted. Author

**N74-19654** Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).

**FATIGUE DESIGN PRACTICE**

K. Ahrensdoerfer. In AGARD Design Against Fatigue Dec. 1973. 18 p. refs. (For availability see N74-19652 11-02)

To define missions for fatigue analysis, mission breakdown and to estimate load spectra for combat or tactical aircraft a high degree of guesstimating is necessary. Available data as to operational mission and load spectra during aircraft development differ greatly, on the other hand these estimated data have a considerable influence on aircraft design. For this reason the aircraft design shall be in such a way that inspections in critical regions are possible and crack propagation is noncritical between inspection intervals. In addition, on all flying aircraft cg - acceleration measurements are necessary. Besides the results of full scale fatigue tests, to have available the complete information for individual life control of flying aircraft. Some aspects of the whole fatigue integrity program are discussed. Author

**N74-19655** McDonnell Aircraft Co., St. Louis, Mo.

**STRUCTURAL FATIGUE ANALYSIS AND TESTING FOR FIGHTER AIRCRAFT**

L. F. Impellizzeri. In AGARD Design Against Fatigue Dec. 1973. 12 p. refs. (For availability see N74-19652 11-02)

The design of fatigue resistant structure includes a combination of fatigue testing analysis. A review of the structural design and development programs of the F-4 and F-15 aircraft highlights their spectrum fatigue testing and indicates that these tests are essential in providing a satisfactory level of structural integrity. An existing procedure is discussed which utilizes Neuber's rule and a cyclicly decaying residual stress function to continually track notch root stress-strain patterns. The technique was developed particularly to predict life for fatigue spectra with either a constant minimum stress or a constant mean stress. A modification of the technique is presented which simplifies its applicability for fatigue spectra with variable minimum and/or mean stress. This also includes variable stress ratios. Life predictions using the modified technique are compared with spectrum test results on 7075-T6 aluminum and 6Al-4V titanium. An example is presented of crack initiation and crack growth caused by out-of-plane bending in a fighter airplane upper wing skin. The local structural detail is analyzed. Fatigue analysis in terms of crack propagation is performed based on the residual tension predicted by the elastic-plastic computer program as the crack extends. Calculated crack growth rates are compared with electron microscope photographs of the upper wing skin fracture surface showing striation spacings. Author

**N74-19656** Grumman Aerospace Corp., Bethpage, N.Y.

**FATIGUE AND FRACTURE CONSIDERATIONS FOR TACTICAL AIRCRAFT**

I. G. Hedrick, L. B. Wehle, and P. D. Bell. In AGARD Design Against Fatigue (date) 15 p. refs. (For availability see N74-19652 11-02)

A review of some of the practical aspects of designing against fatigue is presented. An outline is included of the latest fatigue analysis method used at Grumman and a discussion of some of the more interesting fatigue problems encountered in the evolution of several Grumman aircraft. Some new technological developments are discussed including the F-14 electron beam welded titanium wing carry-through box. The capabilities of some special Grumman inspection techniques to improve quality are reviewed. Author

**N74-19667** Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).

**FULL SCALE FATIGUE REQUIREMENTS FOR RATIONAL FATIGUE LIFE PREDICTION**

H. J. Zocher. In AGARD Design Against Fatigue. Dec. 1973. 14 p. refs. (For availability see N74-19652 11-02)

After discussing a suitable fatigue life evaluation and certification procedure, some requirements are specified for full scale fatigue testing techniques which should be mandatory for future fatigue life substantiation. Test results obtained from two full scale fatigue tests utilizing different testing procedures are compared to service failures. The fatigue test which used the proposed improved testing technique with flight-by-flight loading sequence showed much better results which were in adequate correlation with service experience. Author

**N74-19668** Royal Aircraft Establishment, Farnborough (England) Structures Dept.

**THE ROLE OF THE MAJOR FATIGUE TEST IN THE ACCEPTANCE, CERTIFICATION AND SAFE UTILISATION OF STRIKE AIRCRAFT**

R. D. J. Maxwell. In AGARD Design Against Fatigue. Dec. 1973. 8 p. refs. (For availability see N74-19652 11-02)

The role of the major fatigue test in acceptance, certification, and safe utilization of a strike aircraft is examined from the writing of the aircraft specification to the monitoring of life consumption in service. Attention is focussed on problems associated with defining the test load conditions and interpreting the results in terms of the monitoring system used, including the use of relevant flight load measurements. A summary of the problem areas and suggested minimum standards of fatigue testing, flight measurement and dissemination of the information are included. Author

**N74-19669** National Aero- and Astronautical Research Inst., Amsterdam (Netherlands)

**RE-ASSESSMENT OF FATIGUE PERFORMANCE OF FIGHTER AIRCRAFT**

G. M. VanDijk. In AGARD Design Against Fatigue. Dec. 1974. 19 p. refs. (For availability see N74-19652 11-02)

Fatigue monitoring results obtained by means of strain-gauge recordings are scrupulously compared to the reference full-scale fatigue test loading, finally yielding a relative fatigue severity index. The comparative analysis among other things highlights the importance of ground loads, counting methods and local plasticity at notch roots. A complex notch stress-strain history analysis is carried out to assess the notch root stress history and residual stresses. Finally, a simplified calculation procedure is suggested to account for notch root plasticity and residual stresses. This simplified analysis is a sufficiently accurate substitute of the complex notch stress-strain history analysis. Author

**N74-19660** Societe Nationale Industrielle Aerospatiale, Paris (France).

**DESIGNERS' NEED FOR GENERAL INFORMATION FROM ANALYSIS OF FATIGUE TEST RESULTS AND SERVICE BEHAVIOR**

William Barrois. In AGARD Design Against Fatigue. Dec. 1973. 13 p. refs. (For availability see N74-19652 11-02)

The requirements in fatigue assessment for designing aircraft structures are discussed in terms of interpretative computation, a priori subjective classification of fatigue strength, and prediction analysis. The analyses of fatigue behavior in tests and in service, and the standardization of test loading are discussed along with interpretation methods of fatigue test results, and the establishment of general data on fatigue strength. FOS

**N74-22634\*** Advisory Group for Aerospace Research and Development, Paris (France)

**ABBREVIATED TEST LANGUAGE FOR AVIONICS SYSTEMS**

D. A. Green. Sep. 1972. 61 p. refs. (AGARD-LS-54) Avail. NTIS HC \$6.25

The basic concepts of ATLAS and a selection of some of the more common verbs for constructing test procedures are presented. The overall organization is described of an ATLAS program i.e. the division into preamble and procedural sections. Following this the general structure of an ATLAS statement is discussed to illustrate the general layout of a statement and its internal fields. The fields discussed are as follows: the fixed field which involves the flag, statement number and verb, and the variable field which includes the measured characteristic, noun, statement characteristic, and the evaluation and connection fields. It is shown that the organization of the variable field is determined by the verb used in the fixed field. Author

**X74-73500** Advisory Group for Aerospace Research and Development, Paris (France)

**PHYSICAL VULNERABILITY OF AIRCRAFT, VOLUME 1**

F. D. Orazio. Sep. 1972. 48 p.

(AGARD-AR 47-Vol. 1)

Classified Report

The overall utility of combat aircraft is influenced by the ability of the vehicle to absorb damage and still complete its mission and/or be repaired and returned to service rapidly. The report develops analysis techniques by which this characteristic of the aircraft may be assessed during the initial design phases and measured quantitatively as design features are established. The report also summarizes and evaluates the techniques which have been developed to reduce the physical vulnerability of aircraft.

**X74-73501** Advisory Group for Aerospace Research and Development, Paris (France)

**PHYSICAL VULNERABILITY OF AIRCRAFT, VOLUME 2**

F. D. Orazio. May 1973. 234 p.

(AGARD-AR 47-Vol. 2)

Confidential Report

The overall utility of combat aircraft is influenced by the ability of the vehicle to absorb damage and still complete its mission and/or be repaired and returned to service rapidly. The report develops analysis techniques by which this characteristic of the aircraft may be assessed during the initial design phases and measured quantitatively as design features.

This study was conducted in response to a request from the North Atlantic Military Committee under the management of the Aerospace Applications Studies Committee.

**X74-73502** Advisory Group for Aerospace Research and Development, Paris (France)

**AIRCRAFT VULNERABILITY ANALYSIS, VOLUME 3**

D. Kardels. May 1973. 70 p.

(AGARD-AR 47-Vol. 3)

Secret Report

The report describes a detailed computer model for assessing the physical vulnerability of an aircraft to a variety of weapons and illustrates the use of the model by examples by evaluating three weapon types: 20, 30 and 35 mm shells against the RF 84E aircraft. The model provides sub routines for describing the target and threat, evaluating the effect of the weapon on the components of the aircraft and assessing the impact of damage to component on the survivability of the aircraft. This volume constitutes an appendix to AR 47 Volume 2.

**X74-73506** Advisory Group for Aerospace Research and Development, Paris (France)

**LOW ALTITUDE FLIGHT CONTROL PROBLEMS**

Feb. 1971. 274 p. Presented at Symp. of the Guidance and Control Panel of AGARD, Brussels. 1-3 Sep. 1970.

(AGARD-CP 721)

Classified Report

The papers presented at the Guidance and Control Panel

sponsored Symposium on Low Altitude Flight Control Problems held at NATO Headquarters, Brussels, Belgium in September 1970. The papers address the problem of aircraft flight control conducted at high speeds at very low altitude and in all weather environments.

**X74-73807** Advisory Group for Aerospace Research and Development, Paris (France).

**MILITARY APPLICATIONS OF V/STOL AIRCRAFT. VOLUME 2**

Jun 1973 76 p Presented at 41st Meeting of the Flight Mech Panel of Agard, Brussels, 23-25 Oct 1972 (AGARD-CP-126-Vol-2)

Classified Report

Five papers are contained in this Volume of the Proceedings. Two of the papers are related to the development and service operation of the "Harrier" V/STOL tactical aircraft. Another paper describes the history of the US/FRG V/STOL tactical fighter program. The last two papers are on the subject of future requirements for V/STOL aircraft.

## 03 AUXILIARY SYSTEMS

Includes fuel cells, energy conversion cells, and solar cells, auxiliary gas turbines, hydraulic, pneumatic and electrical systems, actuators, and inverters. For related information see also 09 Electronic Equipment, Nuclear Engineering, and 28 Propulsion Systems

**N73-19001#** Advisory Group for Aerospace Research and Development, Paris (France).

### TECHNICAL EVALUATION REPORT ON 39TH PROPULSION AND ENERGETICS PANEL MEETING ON ENERGETICS FOR AIRCRAFT AUXILIARY POWER SYSTEMS

R. H. Johnson (AFAPL), C. E. Oberly (AFAPL), and R. E. Quigley, Jr. (AFAPL) Nov. 1972 11 p refs Conf. held at Colorado Springs, 12-16 Jun. 1972

(AGARD-AR-50) Avail: NTIS HC \$3.00

An evaluation of a conference to discuss current and future developments in aircraft electrical and auxiliary power systems is presented. Superconductivity phenomena as related to power generation are emphasized. The anticipated requirements imposed on weight, volume, and performance of auxiliary power systems which must operate in a high temperature environment are analyzed. Author

**N73-19030+** Advisory Group for Aerospace Research and Development, Paris (France)

### ENERGETICS FOR AIRCRAFT AUXILIARY POWER SYSTEMS

A. E. Fuhs, ed. (Naval Postgraduate School) Dec. 1972 314 p refs. Mostly in ENGLISH, partly in FRENCH. Proc. of 39th Meeting of the AGARD Propulsion and Energetics Panel held at Colorado Springs, 12-16 Jun. 1972

(AGARD-CP-104) Avail: NTIS HC \$17.75

The proceedings of a conference on the use of superconductivity technology for electrical power generation in aircraft and missiles are presented. The advantages of superconductivity for power generation are described. The subjects discussed include (1) behavior of composite superconducting materials, (2) superconducting generators in aircraft, (3) cryogenic and inductive energy storage, (4) advanced airborne auxiliary power systems, (5) extraction of auxiliary power from air breathing propulsion systems, (6) electrical generation and distribution systems for supersonic aircraft, and (7) non radiating superconducting coils for energy storage. Line drawings, diagrams, charts, tables, and graphs are included to clarify the theoretical aspects. For individual titles, see N73-19031 through N73-19057

### N73-19031 Supertechnology Corp., Boston, Mass

#### STABILITY OF A SUPERCONDUCTOR AS INFLUENCED BY THE SUBSTRATE

Ahmed Elbinderi. In AGARD Energetics for Aircraft Auxiliary Power Systems. Dec. 1972 11 p refs (For availability see N73-19030 10-03)

The effects of substrates on the stability of a superconductor are discussed. Metal cladding in superconductive technology has resulted in improved reliability in design and utilizing of critical current densities as an almost operating condition. The voltage versus current characteristics of superconductors are illustrated. A numerical analysis of the performance of multi-filament superconductors is presented. Several conclusions concerning the electrical properties of superconductors and the effects of various parameters are presented. PNF

**N73-19032** Warwick Univ. Coventry (England) Dept. of Engineering

### THE BEHAVIOUR OF COMPOSITE SUPERCONDUCTING MATERIALS UNDER AC CONDITIONS

A. R. Eastham and R. G. Rhodes. In AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972 11 p refs (For availability see N73-19030 10-03)

Alternating current loss mechanisms in superconductors are described with particular emphasis on the recently developed composite materials. Alternating transport current losses of a wide range of commercially available superconductors of the bare wire and multifilament composite types are presented. The behavior in coil and cable configurations is compared, and it is shown that when self-field effects predominate, little reduction in ac loss results from using multifilament composites as opposed to bare superconducting wire. When transverse field effects predominate, a substantial decrease in loss is possible with composite materials. The effect of transposing the individual filaments within a composite has been investigated, and it is shown that the ac loss can be reduced for a limited range of conditions. Material requirements for low loss conductors are discussed. Author

**N73-19033** Max-Planck-Institut fuer Plasmaphysik, Garching (West Germany)

### USE OF SUPERCONDUCTORS FOR PULSED EXPERIMENTS IN PLASMA PHYSICS

A. P. Martinelli. In AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972 7 p refs (For availability see N73-19030 10-03)

Superconducting magnetics used in plasma experiments and as an essential component of possible future thermonuclear reactors are discussed. Many magnetic configurations for plasma experiments and for reactors as well consist of a stationary magnetic field produced by a superconducting magnet system on which a time dependent magnetic field is superposed. Examples are the sustained field configuration in theta pinch experiments, stellarators during switching on of the helical field, and tokamaks and stellarators during the field pulse used for ohmic heating of the plasma. The effect of pulsed magnetic fields on superconducting coils is studied in a number of non-stabilized single-core and multicore current carrying Nb-Ti superconductors in the form of short samples and small bifilar or inductive coils. Experimental results and calculation methods already reported are complemented and extended. The use and limitation of superconductors in pulsed magnetic configurations as field generating or field shielding coils are reported. Author

### N73-19034 Union Carbide Corp., Tarrytown, N.Y. Linde Div.

#### HIGH FIELD PLASMA ARC-PLATED Nb3Sn SUPERCONDUCTING SOLENOIDS

R. Allar Reese. In AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972 8 p refs (For availability see N73-19030 10-03)

Critical current data on plasma sprayed Nb3Sn conductor for temperatures between 4.2 and 18 K and for magnetic fields up to 92 kilo Oersteds are reported. This data and stabilization data are used to study the effect on the mass of an airborne magnet system operating at temperatures above 4.2 K, and using aluminum vs copper stabilized conductor. The use of high conductivity aluminum is shown to substantially reduce the mass of the system. For the system considered, operation at elevated temperature is shown to result in a larger system mass since the increase in magnetic mass is much greater than the reduction in refrigerator mass. A comparison is made between refrigeration using a closed cycle refrigerator and using liquid helium carried on board. Author

### N73-19035 Magnetic Corp. of America, Cambridge, Mass

#### SUPERCONDUCTIVITY IN STEADY STATE AND PULSED APPLICATIONS FOR FLIGHT VEHICLES

E. J. Lucas, R. J. Thome, and Z. J. J. Stokly. In AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972 9 p. Sponsored in part by AFAPL (For availability see N73-19030 10-03)

The ability of the Type II superconductor to develop high magnetic fields while carrying high current densities naturally leads to applications that are related to power conversion and energy storage. Two major applications are presented: (1) MHD magnet systems and (2) pulsed inductive energy storage systems. The use of superconductors in winding for MHD magnets offer definite advantages in size and weight when compared with room temperature or cryogenic coils using normal conductor. This is primarily due to the higher attainable current density in

the windings and is graphically illustrated in plots which indicate the relative difference in total and component weights for a given field and field volume. As specific examples, weight and volume estimates are given for the magnet systems required for several power levels and a lightweight magnet system currently under development is described. A comparison of inductive energy storage systems making use of normally resistive cryogenically cooled and superconducting coils is presented, as well as a comparison between inductive and capacitive energy storage elements. The current state-of-the-art in pulsed superconducting energy storage is discussed together with a description of recent results using a model coil. Author

**N73-19036** Cranfield Inst. of Technology (England)  
**PROSPECTS FOR SUPERCONDUCTING GENERATORS IN AIRCRAFT**

J. T. Hayden / In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 7 p refs (For availability see N73-19030 10-03)

A review is given of the characteristics of present conventional alternators and aircraft electrical power systems. Preliminary considerations in the use of superconducting windings in 400 Hz alternators indicate that it is difficult to argue a case in favour of using superconducting machines for typical systems in use at present. Further, there is probably a minimum size of 400 Hz generator for which it is practical to introduce superconducting windings below which there is no significant reduction in weight. If systems requiring powers of a few megawatts are considered, then the case for superconducting machines is much more promising providing that some cryogen (such as liquid nitrogen or liquid hydrogen) is already in the aircraft and available for cooling intermediate heat shields. Continued development in lightweight airborne helium refrigerators is also needed. Author

**N73-19037** Laboratoire Central des Industries Electriques (France)

**APPLICATION OF SUPERCONDUCTIVITY TO HOMOPOLAR MACHINERY USING LIQUID METALS**

J. P. Chabrier, G. Fournet, and A. Maillert / In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 4 p refs (For availability see N73-19030 10-03)

The concept of a homopolar machine with multiple discs and superconducting field winding, using liquid metals for the armature sliding electrical contacts is described. The possibilities of these kinds of machines used as motors or power supplies are analyzed. These machines operate with a low voltage and a high armature current, and their main features are an important power-to-weight ratio and a good efficiency. The main results of several studies are presented. These studies have led to the development of a 60 kW flooded rotor homopolar motor operating at low speed (600 r/min). After a short description of the model motor and a brief account of the main test results, the paper concludes with the choice of liquid metals, their applications to more powerful machines and the influence of the use of liquid metals on the machine morphology itself. Author

**N73-19038** Ferranti-Packard Electric, Ltd., Toronto (Ontario)  
**LIGHTWEIGHT SUPERCONDUCTION MAGNET FOR AIRBORNE MHD GENERATORS**

David L. Atherton / In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 9 p refs Sponsored by USAF Aeropropulsion Lab and Canadian Defence Res. Board (For availability see N73-19030 10-03)

A large lightweight saddle-coil superconducting dipole magnet for airborne MHD generators is described. The magnet has a room temperature bore of 27.7 cm, a winding bore of 33 cm, a design field of 4.5 tesla, a magnetic length of 105 cm and a mass of 450 kilograms. The dipole field is generated by pancake winding whose cross sectional outline approximates overlapping circles. Lightweight necessitates high current density, 2,100 A in a 2 mm square conductor containing 200 twisted Nb-Ti filaments in a copper matrix. The Lorentz repulsive force between opposite sides of the magnet is 3850 kilogauss per centimeter of coil length. There are also large compressive forces on the former and repulsive forces between the ends. The mechanical struc-

ture therefore uses a highly stressed lightweight structure of filament wound epoxy glass composite. The dewar uses superinsulation and vapour cooled radiation shields. Vibration and shock analysis and pressure vessel design criteria determine the minimum mass dewar design. Author

**N73-19039** Magnetic Corp. of America, Cambridge, Mass.  
**SUPERCONDUCTING GENERATORS**

Z. J. J. Stekly (Tex. Univ. Austin) and H. H. Woodson / In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 14 p refs Sponsored by United Aircraft Corp. and AFAPL (For availability see N73-19030 10-03)

The development of alternating current machines using superconducting windings is discussed. The design philosophy and details of specific experimental generators are examined. The characteristics of the field winding based on electromagnetic, electro-mechanical, structural, and cryogenic effects are described. The design criteria resulting from the interaction of these parameters are developed. The results of a study of size and weight as a function of power level and frequency are presented. Author

**N73-19040** Westinghouse Electric Corp., Pittsburgh, Pa.  
**RESEARCH LABS**

**SUPERCONDUCTING ELECTRICAL MACHINERY**

C. J. Mole, J. H. Parker, Jr., and L. R. Lowry / In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 15 p refs (For availability see N73-19030 10-03) (Contract F33615-71-C-1591)

The more important types of superconducting machines, the features and problems inherent in such machines, and the more promising applications are reviewed. Both ac and dc superconducting machines are discussed with particular emphasis on the application of ac machines for aircraft use. Recent and current developments in the field are reported. Author

**N73-19041** Commissariat a l'Energie Atomique, Saclay (France)  
**ENERGY STORAGE AND DISCHARGE BY SUPERCONDUCTORS (STOCKAGE ET DECHARGE D'ENERGIE AU MOYEN DU SUPRACONDUCTEURS)**

P. Genevey, G. Prost, J. Sole, and B. Girard / In AGARD Energetics for Aircraft Auxiliary Power Systems Jan. 1971 8 p refs In FRENCH (For availability see N73-19030 10-03)

After an examination of the principles of electric energy storage and discharge, a detailed analysis was made of load operations, trapping, and different problems raised about storage and discharge. The effects of load operation on the utilization of high flux pumping and the discharge that is released by means of rapid transition superconductor commutators are also analyzed. Experimental results are included. Transl. by E. H. W.

**N73-19042** Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Energiewandlung und Elektrische Antriebe

**RESEARCH ON CRYOGENICS AND INDUCTIVE ENERGY STORAGE AT THE DFVLR**

C. Carpentis / In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 7 p refs (For availability see N73-19030 10-03)

The use of superconducting coils for energy storage is discussed. The objective was to find the optimizing parameters and to define the problems which involve the technical use of inductive energy storage. It was determined that (1) the geometry of the coils is essential for optimal performance, (2) high critical current density rather than high critical field is important for optimal devices, and (3) the mass of the superconductor may be small as compared with the needed structural mass.

The development of cryogenically cooled devices, particularly in the presence of time varying fields, is reported. Author

**N73-19043** Centre d'Etudes et Recherches de la Compagnie Electro-Mecanique Le Bourget (France). Groupe d'Etudes Cryotechniques

**NONRADIATING SUPERCONDUCTING COILS FOR ENERGY STORAGE**

M. Gayte, B. Girard, and A. Malardein. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972. 6 p. refs (For availability see N73-19030 10-03)

The characteristics of superconducting coils as energy storage elements are investigated together with the main problems affecting their design: electromagnetic forces, energy radiation and discharge losses. An ellipsoid coil set into a shielding coil is then described; its outer field is zero and its shape suitable to withstand the electromagnetic forces. The relation stored energy/superconductor volume is particularly high. An experimental coil located in a stainless steel cryostat was built allowing for the control of the calculation method and the study of the effect of the difference between the real and the theoretical shapes. Author

N73-19044. Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany)

#### ADVANCED POWER GENERATION IN MISSILES

O. Stumpf, H. Loesser, and H. Shari. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972. 13 p. refs (For availability see N73-19030 10-03)

Power generating systems and their application in modern missiles for the production of hydraulic and/or electric energy are discussed. A system weight analysis for 5 different systems is described which shows the application regimes in terms of output power and mission time. Details of recently developed components are given. Author

N73-19045. AirResearch Mfg. Co., Phoenix, Ariz.

#### ADVANCED AIRBORNE AUXILIARY POWER SYSTEM

D. F. Swenski, L. W. Norman, and A. D. Meshew. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972. 12 p. ref (For availability see N73-19030 10-03)

An advanced auxiliary power unit (APU) was combined with an accessory drive system to form an auxiliary power system (APS). This APS was used as an exploratory development test bed for the development of advanced technology components. The APS included a 300 equivalent shaft horsepower APU configured to furnish bleed air from a split flow impeller and shaft power at 130 F., sea level ambient conditions. The APS was designed to provide standby power separate from the accessories and engine drive train, checkout engine starting, and emergency power through a high-speed torque converter. The design of the APS was intended to form a test bed representing the optimum configuration as determined from a systems analysis, with a high degree of flexibility such that the components thus developed may be applicable to many other future APS designs. Author

N73-19046. Kloeckner-Humboldt-Deutz A.G., Oberursel (West Germany)

#### AUXILIARY POWER UNITS FOR SECONDARY POWER SYSTEMS

Erwin Schnell. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972. 9 p. (For availability see N73-19030 10-03)

The design principles for the auxiliary power units of a secondary power system for use in aircraft are presented. The single shaft turbine is compared with the free power turbine for auxiliary power unit applications. The equipments operated by the auxiliary power unit is discussed and the components of the electrical system are analyzed. Author

N73-19047. Messerschmitt-Boelkow G.m.b.H., Munich (West Germany)

#### PULSE JET ENGINE AS A SOURCE OF ENERGY FOR AUXILIARY POWER UNITS: PULSE GAS TURBINE WITHOUT COMPRESSOR

W. K. Eck. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1972. 12 p. (For availability see N73-19030 10-03)

A short survey of the elements of an intermittent pulse jet engine, open on both sides, which has been tested up to the supersonic speed is presented. The results show that such an airbreathing unit can also be used as a gas generator acting upon a turbine rotor for taking off mechanical power. The basic design of the engine consists of a thin-walled welded steel

construction of conical and cylindrical shape, without any mechanically moved, rotating or oscillating parts. A spark plug for intermittent external ignition for starting and a fuel control device belong to the basic version of the engine. The turbine is driven by the hot gases which are intermittently expelled from the combustion chamber. The power unit can also be selectively used after diversion as a propulsion engine. The low costs of manufacturing and maintenance for such engines are pointed out. The influence of the most important parameters is explained. The auto-ignition, based on the principle of residual gas including shock wave rate, is an important functional feature of the pulse jet engine. Author

N73-19048. Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio. Auxiliary Power Units

#### DUAL MODE AUXILIARY POWER UNIT FOR HIGH MACH AIRCRAFT

Beryl L. McFadden, Jr. and Richard E. Quigley, Jr. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1973. 9 p. refs (For availability see N73-19030 10-03)

Advanced high performance aircraft are projected to employ ramjet, turboramjet, and rocketramjet engines. Since ramjet engines do not incorporate rotating members, they cannot provide shaft horsepower for aircraft accessories and flight control systems. Therefore, some form of auxiliary power source will be required to furnish the hydraulic, electric, pneumatic, and shaft power for the various aircraft systems during flight, thus the auxiliary power source must become the prime and only source of shaft power during high speed flight. Various power source configurations to accomplish this are reviewed with emphasis on the potential of a single dual mode power source sized to provide all flight vehicle power throughout the entire operating regime of the aircraft including ground standby. Since they are totally independent, such a configuration will permit design optimization of both the main propulsion engines and the power system. Author

N73-19049. British Aircraft Co., Preston (England). Military Aircraft Division

#### INTEGRATION OF AUXILIARY POWER SYSTEMS WITH THE MULTI-SPOOL ENGINE

Len W. Milsom. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1973. 8 p. (For availability see N73-19030 10-03)

As engine technology advances certain engine/airframe interface problems arise with aircraft auxiliary power systems. Using a modern strike aircraft as the principal example, this paper examines the difficulties in meeting the airframe mechanical power requirements of generating excessive wasted energy in air bleed systems and of dissipating the waste heat from engine and airframe accessories. Much closer collaboration between airframe and engine contractors at the early stage of an aircraft project, in order to develop a combined approach to the solution of these problems, is recommended. Author

N73-19050. Motoren-Und Turbinen-Union Muenchen G.m.b.H. (West Germany)

#### EXTRACTION OF AUXILIARY POWER FROM AIRBREATHING PROPULSION SYSTEMS

Klaus Bauerfeind. *In* AGARD Energetics for Aircraft Auxiliary Power Systems. Feb. 1973. 13 p. (For availability see N73-19030 10-03)

The characteristics of gas turbine engines for use as auxiliary power sources are discussed. The direct supply of mechanical power and pressurized air from turbines is examined. The most important criteria for the auxiliary power sources are identified as: (1) maximum possible power delivery points, (2) compressor surge margins, (3) effect on handling characteristics of aircraft, and (4) effect on windmilling characteristics of turbine engine. Data are presented in the form of graphs to show interrelationships of turbine engine parameters. Author

N73-19051. Politecnico di Milano (Italy). Ist. di Macchine

#### A METHOD FOR PRELIMINARY ANALYSIS OF MHD GENERATOR PERFORMANCE

C. Casci, A. Codice, and U. Ghezzi. *In* AGARD Energetics for

Aircraft Auxiliary Power Systems Feb. 1972 12 p refs (For availability see N73-19030 10-03)

The characteristics of magnetohydrodynamic generators for aircraft and spacecraft applications are discussed. A method for analyzing the parameters of a magnetohydrodynamic generator is developed. The analysis is obtained by fixing the total enthalpic difference between the inlet and outlet sections of the duct and by examining the various possibilities through which such a condition may be achieved. Thermodynamic and electromagnetic quantities are studied in relation to the velocity difference between the inlet and outlet sections of the duct and by some other parameters, such as expansion ratio and form factor of the duct. Author

N73-19062 Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio

#### DEVELOPMENTS IN AIRCRAFT ELECTRICAL POWER SYSTEMS

Robert H. Johnson. In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 7 p refs (For availability see N73-19030 10-03)

A summary of Air Force research and development programs in aircraft electrical power systems and components is presented. The planning process used to validate research programs is discussed with emphasis on the resultant motivation to develop specific classes of technology. Specific programs discussed are: (1) solid state power controllers, (2) gate controlled switch technology, (3) solid state electric power simulator tests, and (4) high temperature electrical generators, wires, and connectors. Author

N73-19063 Vought Aeronautics, Dallas, Tex.  
APPLICATION OF SOLID STATE SWITCHING AND MULTIPLEXING TO AIRCRAFT ELECTRICAL SYSTEMS

Clyde W. Jones (AFAPL) and Jim Courter. In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1973 9 p (For availability see N73-19030 10-03)

The application of solid state switching, multiplexing, and electrically programmable logic to aircraft electrical systems is discussed. The effects of the use of solid state switching technology on electrical system weight, reliability, electromagnetic interference, and quality of power delivered to loads are analyzed. A summary of problems encountered with proposed solutions, during a program in which a completely solid state electrical system for an A-7 aircraft was evaluated, is included. Areas of improvement and expanded capability are also enumerated. Author

N73-19064 Royal Aircraft Establishment, Farnborough (England)  
Engineering Physics Dept.  
ELECTRICAL GENERATION AND DISTRIBUTION SYSTEMS FOR FUTURE SUPERSONIC AIRCRAFT

A. Bainbridge. In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 7 p refs (For availability see N73-19030 10-03)

The size of the total electrical load and the temperature range over which some components will have to operate make it necessary to study new generation and distribution techniques to satisfy the demands of future aircraft flying in the supersonic or hypersonic range. This paper is restricted to supersonic aircraft and discusses recent proposals for improved distribution systems incorporating solid state switching and using remote control of protective devices through a multiplexed system. The scope for high temperature wiring is briefly discussed and a few recent developments in generators and power cables are described, since the generating system is particularly vulnerable to extreme environmental conditions. Author

N73-19065 Societe d'Applications des Machines Motrices S.A., Issy-les-Moulineaux (France)  
ADIABATIC COMPRESSION OF OILS EASILY MEASURED FROM PUMP AND MOTOR YIELD [COMPRESSION ADIABATIQUE DES HUILES MEASUREES AISEES DES RENDEMENTS DES POMPES ET MOTEURS]

Jacques Faisandier. In AGARD Energetics for Aircraft Auxiliary Power Systems Dec. 1972 8 p. In FRENCH (For availability see N73-19030 10-03)

Formulas are reported for calculating the influence of adiabatic oil compression on transmission power of hydraulic systems. Calculations were also made of pump and motor destruction, and the value of thermal destruction due to oil overheating in the pumps. Transl. by E.H.W.

N73-19066 British Aircraft Corp., Weybridge (England).

#### PNEUMATICS IN SUPERSONIC ENERGETICS

John Wotton. In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1973 15 p (For availability see N73-19030 10-03)

A pneumatics orientated integrated system concept developed for subsonic civil aircraft is examined in its relation to supersonic operation. The principle of waste heat extraction for the generation of auxiliary power supplies is found to be even more viable due to greater cabin pressure differential during cruise, and the level of engine compressor tapping required in consequence. The economics of engine bleed are examined in the light of virtually free electrical generation in the method employed. Pneumatic power conversion is shown to be at least competitive with hydraulic and other equivalents, and the requirements of power flying controls to be satisfactorily met. Author

N73-19067 Pisa Univ. (Italy). Facolta di Ingegneria.  
THEORETICAL MODELS FOR PLASMA MOTION IN PULSED COAXIAL HYDROMAGNETIC GUNS

M. Andrenucci, M. Caprili, and R. Lazzeretti. In AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 17 p refs (For availability see N73-19030 10-03)

A theoretical study of the performance of pulsed coaxial plasma guns is described. The electromechanical equations are derived for a snowplow model allowing for a variable initial mass-loading distribution. Computer results for two families of distributions are presented and analyzed. The values of the system parameters that yield highest value of kinetic efficiency are determined for widely varied conditions. A modified model allowing for the actual variation of the magnetic pressure with the radius is formulated and preliminary results for this model are discussed.

Finally an account is given of the numerical methods employed in solving the sets of coupled differential equations describing the system in the assumed models. Author

## 04 BIOSCIENCES

Includes aerospace medicine, exobiology, radiation effects on biological systems, physiological and psychological factors. For related information see also: 05 Biotechnology.

**N71-20076#** Advisory Group to Aerospace Research and Development, Paris (France)

**GLOSSARY OF AEROSPACE MEDICAL TERMS, ENGLISH-FRENCH AND FRENCH-ENGLISH [GLOSSAIRE DES TERMES UTILISES EN MEDECINE AEROSPATIALE, ANGLAIS-FRANCAIS ET FRANCAIS-ANGLAIS]**

D I Fryer, ed. Jan 1971. 54 p. ref. In ENGLISH and FRENCH. Revised.

(AGARD-AG-153-71; AGARDOGRAPH-153) Avail NTIS

A glossary of new terms is presented by the AGARD Aerospace Medical Panel. The terms are limited to those having a specific meaning in Aerospace Medicine or peculiar to that field of study.

Author

**N71-20351#** Advisory Group for Aerospace Research and Development, Paris (France)

**ADAPTATION AND ACCLIMATISATION IN AEROSPACE MEDICINE**

H J Grunhofer, ed. Mar 1971. 202 p. refs. Presented at 27th Aerospace Med. Panel Meeting, Garmisch-Partenkirchen, West Germany, 14-18 Sep 1970.

(AGARD CP 82-71) Avail NTIS

**CONTENTS**

1 ACOUSTIC FATIGUE OF HUMANS EXPOSED TO NOISE. G C Tolhurst (ONR, Arlington, Va.) 8 p. refs. (See N71-20352 09-04)

2 GROWTH AND RECOVERY OF TEMPORARY THRESHOLD SHIFTS FOLLOWING EXTENDED EXPOSURE TO HIGH LEVEL CONTINUOUS NOISE. J D Mosko and J L Fletcher (Army Med Res Lab, Fort Knox, Ky.) 7 p. refs. (See N71-20353 09-04)

3 CARDIAC AND NEURAL EFFECTS OF RADAR WAVELENGTHS. A H Frey (Randomline, Inc.) 6 p. (See N71-20354 09-04)

4 FLIGHT CREW ADAPTABILITY TO THE HELICOPTER VIBRATION ENVIRONMENT. J W Danaher (Matrix Corp, Alexandria, Va.) 5 p. refs. (See N71-20355 09-04)

5 VIBRATION IN VSTOL AIRCRAFT. W L Jones (NASA, Washington, D.C.) 10 p. refs. (See N71-20356 09-04)

6 EFFECT OF POSTURE ON TOLERANCE TO POSITIVE (G sub z) ACCELERATION. R J Crossley and D H Glaister (Royal Air Force Inst of Aviation Medicine, Farnborough, England) 8 p. refs. (See N71-20357 09-04)

7 EFFECTS OF POSITIVE G<sub>y</sub> ACCELERATION ON BLOOD OXYGEN SATURATION AND PLEURAL PRESSURE RELATIONSHIPS IN DOGS BREATHING FIRST AIR THEN LIQUID FLUOROCARBON IN A WHOLE BODY WATER IMMERSION RESPIRATOR. D J Sass, L L Bitman, P E Caskey, J Greenleaf, and N Banchero et al. (Mayo Clinic) 15 p. refs. (See N71-20358 09-04)

8 AGE AND EXERCISE AS FACTORS INFLUENCING OSTEOPOROSIS, BONE STRENGTH AND ACCELERATION TOLERANCE. L E Kazarian and H E Von Gierke (AMRL) 21 p. refs. (See N71-20359 09-04)

9 PROBLEMS OF ADAPTATION TO LONG RANGE LARGE SCALE AERIAL TROOP DEPLOYMENT. S C Knapp (Army Aeromedical Research Lab) 14 p. refs. (See N71-20360 09-04)

10 IMPULSIVENESS AND ANXIETY RELATED TO PERCEPTUAL MOTOR PERFORMANCE. E S Barratt (Texas Univ, Galveston) and G Tolhurst (ONR, Arlington, Va.) 5 p. refs. (See N71-20361 09-04)

11 EFFECTS ON HUMAN PERFORMANCE OF COMBINED ENVIRONMENTAL STRESSES. W F Grether (AMRL) 10 p. refs. (See N71-20362 09-04)

12 THE NOVEL TASK AS A MEASURE OF PERFORMANCE UNDER ENVIRONMENTAL STRESS. M F Allnutt (Royal Air Force Inst of Aviation Medicine, Farnborough, England) 4 p. refs. (See N71-20363 09-04)

13 IS LABORATORY EXPERIMENTATION USEFUL FOR STUDYING HUMAN ADAPTATION TO UNINHABITABLE SENSORY ENVIRONMENTS? R Angiboust (Centre D'Enseignement Et De Recherches De Medecine Aeronautique, Paris, France) 7 p. (See N71-20364 09-04)

14 THE PSYCHOTHERAPEUTIC METHOD IN AVIATION PSYCHIATRY IN THE TREATMENT OF SOME SYNDROMES OF A REACTIVE CHARACTER. L Longo (Italian Air Force Psycho Physiological Inst., Naples) 10 p. refs. (See N71-20365 09-04)

15 EXPERIMENTAL RESEARCH ON HEAT BALANCE OF ATHLETES OF VARIOUS SPECIALTIES, DURING MUSCULAR EXERCISE IN DIFFERENT THERMAL ENVIRONMENTS. P Rota (Italian Air Force Aerospace Medical Center, Rome, Italy) and A Todaro (Accident Prevent. Natl. Agency Res. Center) 8 p. refs. (See N71-20366 09-04)

16 ENERGY METABOLISM DURING EXPOSURE TO EXTREME ENVIRONMENTS. C F Consolazio, H L Johnson, and H J Krzywicki (Army Medical Research and Nutrition Lab) 11 p. refs. (See N71-20367 09-04)

17 METABOLIC IMBALANCES AND BODY HYPOHYDRATION DURING FOOD DEPRIVATION (10 DAYS). C F Consolazio, H L Johnson, and H J Krzywicki (Army Medical Research and Nutrition Lab) 8 p. refs. (See N71-20368 09-04)

18 THE INFLUENCE OF ENVIRONMENTAL FACTORS IN AIRCRAFT CARRIER LANDINGS AND ACCIDENTS. C A Brinson (Dunlap and Associates, Inc., Santa Monica, Calif.) 7 p. refs. (See N71-20369 09-02)

19 EFFECT OF ACUTE AND CHRONIC EXPOSURE TO 21 MM HG AMBIENT P SUB CO<sub>2</sub> ON EXERCISE RESPONSE OF NORMAL MAN. R D Sinclair, J M Clark, and B E Welch (School of Aerospace Medicine) 9 p. refs. (See N71-20370 09-04)

20 VOLITIONAL CONTROL OF VISUAL ACCOMMODATION. R J Randle (NASA Ames Research Center, Moffett Field, Calif.) 13 p. refs. (See N71-20371 09-04)

**N71-20352#** Office of Naval Research, Arlington, Va.

**ACOUSTIC FATIGUE OF HUMANS EXPOSED TO NOISE**

Gilbert C Tolhurst. In: AGARD: Adaptation and Acclimatization in Aerospace Med. Mar 1971. 8 p. refs. (See N71-20351 09-04) Avail NTIS

Since human fatigue is not truly a precise phase, by borrowing an analogy from the material sciences, an attempt has been made to outline both physiologically and psychologically the limits and ranges of the response to acoustic stimuli, termed elasticity, deformation and destruction. The precision is no better or no worse than the same terms applied to metal fatigue. Present damage-risk criteria, if strictly applied by industry, the military, or by social services organizations, should materially reduce the incidence of noise induced hearing losses to approximately 85 to 95 percent of a population. Considerable amounts of data are needed to allow any particular individual's susceptibility to be predicted with precision. While considerable research effort has yielded ever increasingly elegant methods to quantify potentially hazardous noise environments as well as communications interfering ones, the consequences of prolonged noise exposure need extensive experimental validation.

Author

**N71-20353#** Army Medical Research Lab, Fort Knox, Ky. Experimental Psychology Div.

**GROWTH AND RECOVERY OF TEMPORARY THRESHOLD SHIFTS FOLLOWING EXTENDED EXPOSURE TO HIGH LEVEL CONTINUOUS NOISE**



James D. Mosko and John L. Fletcher. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar. 1971. 7 p. refs. (See N71-20351 09-04)  
 Avail NTIS

Requirements of long term operations for both air and ground military personnel have increased in recent years, and the probability of having such personnel exposed to hazardous noise levels and durations has increased. Research was undertaken to investigate the effects of long term exposure on the auditory thresholds for discrete tonal signals and the recovery from any temporary threshold shift. Evidence indicates a gradual growth in temporary threshold shift (TTS) over 12-16 hours of exposure, with an asymptotic TTS configuration extending through 48 hours of exposure. Full recovery is attained in approximately 23-24 hours after cessation of exposure. The results of this research could lead to reconsideration of the damage risk criteria for noise exposure and to the design of protective devices. Author

**N71-20354#** Randomline Inc., Willow Grove, Pa.  
**CARDIAC AND NEURAL EFFECTS OF RADAR WAVELENGTHS**

Allan H. Frey. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar. 1971. 6 p. (See N71-20351 09-04)  
 Avail NTIS

Results of experimentation on the cardiac effects of UHF energy are reviewed. A series of three experiments were conducted; the first two experiments used isolated frog hearts and the third used intact frogs. The UHF energy was synchronized with events in the ECG in an attempt to drive the heart. Synchronization with the R wave had significant effects. Author

**N71-20355#** Matrix Corp., Alexandria, Va.  
**FLIGHT CREW ADAPTABILITY TO THE HELICOPTER VIBRATION ENVIRONMENT**

J. W. Danaher. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar. 1971. 5 p. refs. Sponsored by ONR. (See N71-20351 09-04)  
 Avail NTIS

Interpretations of research literature concerning the effects of vibration on man are presented. Described are some effects of vibration on the performance of certain flight crew tasks required by emerging helicopter missions. Specifically, the implications for long duration, search and rescue, and assault support missions are discussed. Tasks associated with the operation of various human sensory systems, digital input devices, and helmet-mounted and other displays are also analyzed. Areas requiring further research are defined and engineering approaches to the solution of the helicopter vibration problem are outlined. Author

**N71-20356#** National Aeronautics and Space Administration  
 Washington, D.C.  
**VIBRATION IN V-STOL AIRCRAFT**

Walton L. Jones. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar. 1971. 10 p. refs. (See N71-20351 09-04)  
 (NASA-TM-X-66956) Avail NTIS CSCL 065

The ride comfort program being conducted at Langley Research Center is described. This program assesses those characteristics of V-STOL vibration which influence human comfort. Vehicle measurements correlated with the results from simulation experiments will yield the recommended ride comfort criteria. Also described is: (1) a planned study of an active vibration isolation system designed to eliminate approximately 90% of the vibration at the primary frequency of 18 cycles per second, and (2) a ride comfort simulator having three degrees of freedom, a payload capacity of 5,000 pounds, and vertical and lateral direction having peak to peak double amplitude of six inches with plus and minus 0.5 g. A.L.

**N71-20357#** Royal Air Force Inst. of Aviation Medicine  
 Farnborough (England)

**EFFECT OF POSTURE ON TOLERANCE TO POSITIVE (Gz) ACCELERATION**

R. J. Crossley and D. H. Glaister. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar. 1971. 8 p. refs. (See N71-20351 09-04)  
 Avail NTIS

The effect of varying the posture of eight subjects on their relaxed greyout thresholds has been studied. Six angles of the seat back between 70 deg to the horizontal and 15 deg, and rates of onset of acceleration of 1.0 g/sec and 0.1 g/sec were used. The g thresholds of all subjects, with both rates of onset, increased as the back angle decreased and were directly proportional to the reciprocal of the vertical distance between the eye and the haemodynamic indifference point. The degree of neck flexion was observed to have little effect on the thresholds at any one angle. Four subjects also wore an anti-g suit for further threshold determinations with seat back angles of 70 deg, 30 deg and 15 deg. The increase in thresholds produced by the anti-g suit was the same for each angle. Comparison of the thresholds observed with the two rates of onset show that the 0.1 g/sec rate leads to higher thresholds than the 1.0 g/sec rate. These studies indicate that a near supine posture combined with an anti-g suit can provide relaxed g thresholds in the region of 6 to 8 g while permitting adequate forward vision. Such a posture would have the added advantage of exposing the aircrew to -g sub-x acceleration during ejection. Author

**N71-20358#** Mayo Clinic, Rochester, Minn. Graduate School of Medicine

**EFFECTS OF POSITIVE G<sub>y</sub> ACCELERATION ON BLOOD OXYGEN SATURATION AND PLEURAL PRESSURE RELATIONSHIPS IN DOGS BREATHING FIRST AIR, THEN LIQUID FLUOROCARBON IN A WHOLE BODY WATER IMMERSION RESPIRATOR**

D. J. Sass, E. L. Ritman, P. E. Caskey, J. Greenleaf, N. Banchemo et al. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar. 1971. 15 p. refs. Sponsored in part by Navy. (See N71-20351 09-04)  
 (Grant NGR 24 003 001, Contract F41609 69-C 0058, Grant NIH HE 3532)  
 (NASA CR-117199) Avail NTIS CSCL 065

A total body water immersion, mechanical respiration, body support assembly has been used with dogs on the human centrifuge to compare effects of -1 G<sub>y</sub> and -6 G<sub>y</sub> acceleration on cardiovascular and respiratory function in dogs under three conditions: (1) normal respiration in air; (2) totally immersed in a saline filled respirator chamber providing control of respiratory rate, tidal and residual volumes when breathing air or oxygen; and (3) when respired in the same manner with oxygenated liquid fluorocarbon. The results indicate that: (1) arterial hypoxemia due to dependent pulmonary arteriovenous shunting caused by acceleration is not minimized by water immersion alone; (2) dogs can be respired with liquid fluorocarbon for four hours or longer without clinical signs of respiratory distress; (3) liquid respiration prevented dependent pulmonary arteriovenous shunting at -6 G<sub>y</sub>; (4) vertical gradients in pleural pressure gradients were approximately 0.7 cm H<sub>2</sub>O/cm vertical distance between pleural catheter tips in air breathing dogs in contrast to greater than 1.0 cm H<sub>2</sub>O/cm vertical distance in liquid breathing experiments; and (5) liquid breathing prevented inertial displacements of the heart and other mediastinal structures to dependent sites in the thorax and roentgenographically evident pulmonary atelectasis in dependent regions. Author

**N71-20359#** Aerospace Medical Research Labs., Wright Patterson AFB, Ohio

**AGE AND EXERCISE AS FACTORS INFLUENCING OSTEOPOROSIS, BONE STRENGTH, AND ACCELERATION TOLERANCE**

L. E. Katanian and H. E. Von Gierke. In AGARD Adaptation and

Acclimatisation in Aerospace Med. Mar 1971 21 p refs (See N71-20351 09-04)

(AMRL TR-70-74) Avail NTIS

Spinal injury associated with escape from high performance aircraft has tended to occur more frequently in the aged than the younger aircrewman population. Although an age influence for this trauma has not been clearly demonstrated, it must be hypothesized. Osteoporosis is part of the normal aging process and accompanies most diseases affecting man. Disuse osteoporosis appears to be an exaggeration of the normal aging process. Mechanical stress, such as that produced by exercise and physical activity, is necessary for the retention of skeletal mass and may be a specific influence in controlling the adverse effects of osteoporosis. To produce a partial answer to the questions raised and their potential operational significance, 24 adult rhesus monkeys were subjected to 60 days of physical inactivity. The results show a decrease in spinal impact tolerance in terms of vertebral body fracture when experimentally produced osteoporotic primates were exposed to whole body longitudinal spinal impact. Histopathological examination at points of tendinous and ligamentous attachment show increased bone modeling activity. Author

**N71-20360# Army Aeromedical Research Lab. Fort Rucker Ala. PROBLEMS OF ADAPTATION TO LONG RANGE LARGE SCALE AERIAL TROOP DEPLOYMENT**

Stanley C. Knapp. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar 1971 14 p refs (See N71-20351 09-04). Avail NTIS

Stresses and adaptation problems demonstrated during large scale, long range, rapid reaction time, aerial troop deployments are described. NATO Exercise REFORGER; and other recent large scale aerial troop deployments are discussed. Author

**N71-20361# Texas Univ. Galveston. Dept. of Neurology and Psychiatry**

**IMPULSIVENESS AND ANXIETY RELATED TO PERCEPTUAL MOTOR PERFORMANCE**

Ernest S. Barratt and Gilbert Tothurst (ONR, Arlington, Va.). In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar 1971 5 p refs (See N71-20351 09-04).

(Contract N00014-68 A 0105 0002)

Avail NTIS

Anxiety and impulsiveness have been studied within a conceptual framework that recognizes four classes of variables: (1) everyday life experiences; (2) psychometric tests and psychometric interviews; (3) laboratory behavioral measures; and (4) psychophysiological measures. The overall goal was to describe anxiety and impulsiveness across all four classes of variables for both stress and nonstress conditions. Examples of the relationship of the interaction of impulsiveness and anxiety to perceptual motor performance are presented within the context of a brief discussion of the overall research program. Author

**N71-20362# Aerospace Medical Research Lab. Wright Patterson AFB, Ohio**

**EFFECTS ON HUMAN PERFORMANCE OF COMBINED ENVIRONMENTAL STRESSES**

Walter F. Grether. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar 1971 10 p refs (See N71-20351 09-04). Avail NTIS

Research studies of environmental effects normally expose subjects to only one stress at a time while in operational flying there are usually several stresses acting simultaneously. The possibility exists that effects of such combined stresses may be greater than would be predicted from single stress studies. There have been relatively few laboratory studies of human performance in which the subjects have been exposed to such combined stresses. A critical review is presented of these past studies from the particular viewpoint of whether performance decrements from combined stresses are more severe than would be predicted from single stress

studies. Although the number of past studies is not sufficient to present a consistent or conclusive picture, they do suggest that combinations of environmental stresses do not present a special hazard in flying that could not be anticipated from results of single stress studies. Author

**N71-20363# Royal Air Force Inst. of Aviation Medicine, Farnborough (England)**

**THE NOVEL TASK AS A MEASURE OF PERFORMANCE UNDER ENVIRONMENTAL STRESS**

M. F. Allnutt. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar 1971 4 p refs (See N71-20351 09-04). Avail NTIS

Experiments were conducted to determine human performance on a complex reasoning test under the stresses of temperature and altitude. In the analysis of the data special attention was given to those situations in which the subjects' first acquaintance with the task was under the stress condition. The experimental work along with a discussion of the advantages and disadvantages of using a novel task to assess performance under environmental stress is briefly discussed. Author

**N71-20364# Centre d'Enseignement et de Recherches de Medecine Aeronautique, Paris (France). Lab. Central de Biologie Aeronautique**

**IS LABORATORY EXPERIMENTATION USEFUL FOR STUDYING HUMAN ADAPTATION TO UNINHABITABLE SENSORY ENVIRONMENTS? [L'EXPERIMENTATION EN LABORATOIRE EST-ELLE PERTINENTE POUR ETUDIER L'ADAPTATION DE L'HOMME AUX ENVIRONNEMENTS SENSORIELS INHABITUELS]**

Roger Angiboust. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar 1971 7 p. In FRENCH, ENGLISH summary (See N71-20351 09-04).

Avail NTIS

Two experiments were conducted to study the adaptation of voluntary subjects to a degraded sensorial environment. These experiments showed that: (1) The behavioral and physiological response to an unusual environment depends on the subjects' level of education and personal interest in the test; (2) Adaptation to an unusual environment can be modified by giving to the tested subjects psychoanaleptics which induce behavioral manifestations of inadaptation in subjects who had been so far free from them. In light of these experiments, it appears that, for the subject, the significant stimulus is not the physical one or the arrangement of physical stimuli which excites his senses, but the meaning which he gives to the overall experiment situation, and the way he feels it. The importance of the decrement of physical stimuli does not affect the behavioral manifestations of inadaptation. The same physical environment can be felt as a neutral, indifferent stimulus or, on the contrary, as an aggressive, nociceptive stimulus. Author

**N71-20365# Italian Air Force Psycho Physiological Inst. Naples. THE PSYCHOTHERAPEUTIC METHOD IN AVIATION PSYCHIATRY IN THE TREATMENT OF SOME SYNDROMES OF A REACTIVE CHARACTER**

L. Longo. In AGARD Adaptation and Acclimatisation in Aerospace Med. Mar 1971 10 p refs (See N71-20351 09-04). Avail NTIS

The usefulness in aviation psychiatry of psychotherapeutic treatment of some syndromes of a reactive character is shown through the description of 7 cases synthetically reported in their most indicative constitutive elements and in the psychodynamic modality of the relative psychotherapeutic treatment. Stress was laid on the advantages that accrue from the fact of being able to carry out the therapy in the environment itself and on the favorable implications that can derive from it both on the strictly clinical plane and on the more specific one of maintaining and repairing flight fitness. Author

**N71-20366#** Italian Air Force Aerospace Medical Center, Rome (Italy)

**EXPERIMENTAL RESEARCH ON HEAT BALANCE OF ATHLETES OF VARIOUS SPECIALTIES, DURING MUSCULAR EXERCISE IN DIFFERENT THERMAL ENVIRONMENTS**

Paolo Rota and Antonio Todaro (Accident Prevent. Natl. Agency Res. Center) *In AGARD Adaptation and Acclimatization in Aerospace Med.* Mar 1971 8 p refs (See N71-20351 09-04)  
Avail NTIS

Athletes trained to different muscular exercises (long distance runners and sprinters) carried out work tests under conditions of thermal neutrality and in hot environments. During the tests physiological parameters were recorded (central and skin temperatures, sweat loss, oxygen intake, work load, etc.) in order to calculate heat balance. Based on accumulated data, the behavior of thermal regulation, in respect to the different athletic specialties of the subjects tested, is discussed. Author

**N71-20367#** Army Medical Research and Nutrition Lab., Denver, Colo. Bioenergetics Div.

**ENERGY METABOLISM DURING EXPOSURE TO EXTREME ENVIRONMENTS**

C. F. Consolazio, H. L. Johnson, and H. J. Krywicki *In AGARD Adaptation and Acclimatization in Aerospace Med.* Mar 1971 11 p refs (See N71-20351 09-04)  
Avail NTIS

The energy requirements in a cold environment are practically unchanged as compared to a temperate environment, except for the 2 to 5% increase due to the wearing of the heavy clothes and footwear, providing that the individual is adequately clothed. However, the daily energy requirements for men living and working in a hot environment are increased. This is related to the increased requirement of the circulation in heat transport, the increased action of the sweat glands, increased caloric loss due to sweat vaporization and to the increase in body temperature. Balance studies including losses of nutrient in sweat indicate that these excretions are appreciable under conditions of profuse sweating. In the past, with the exception of sodium, very few investigators have recognized the fact that the mineral losses in sweat could be appreciable. The total mineral loss should include the mineral loss in sweat. This in turn would help in estimating more realistically the minimal daily allowances of minerals. Author

**N71-20368#** Army Medical Research and Nutrition Lab., Denver, Colo. Bioenergetics Div.

**METABOLIC IMBALANCES AND BODY HYPOHYDRATION DURING FOOD DEPRIVATION (10 DAYS)**

C. F. Consolazio, H. L. Johnson, and H. J. Krywicki *In AGARD Adaptation and Acclimatization in Aerospace Med.* Mar 1971 8 p refs (See N71-20351 09-04)  
Avail NTIS

During studies of 6 men who fasted completely for 10 days, significant metabolic stresses developed which could eventually lead to serious abnormalities. These observations included great body hypohydration resulting in large body weight losses, large nitrogen and mineral losses, and a marked ketosis. These findings are not unusual since both the body fat and protein stores must be utilized as energy sources. The maintenance of normal blood carbohydrate levels require a known quantity of protein breakdown. As a result, it was suggested that low anti-ketogenic diets and adequate mineral supplementation could prevent the marked ketosis, minimize protein catabolism, maintain fluid balance, and decrease the electrolyte excretion. EKG's and EEG's were normal in both groups during the entire study. It appears that restricted diets containing less than 500 calories/day are inadequate for short term performance. Although they spared water, the protein catabolism was still a major problem. Author

**N71-20369#** Dunlap and Associates, Inc., Santa Monica, Calif.  
**THE INFLUENCE OF ENVIRONMENTAL FACTORS IN AIRCRAFT CARRIER LANDINGS AND ACCIDENTS**

Clyde A. Britton *In AGARD Adaptation and Acclimatization in Aerospace Med.* Mar 1971 7 p refs (See N71-20351 09-04)  
Avail NTIS

An analysis of carrier landing accidents during a five year period (1965-1969) showed that environmental causal factors contributed to 27% of all jet landing accidents. Pitching deck was the most frequently cited environmental causal factor and was cited in 15% of the landing accidents. The F4 aircraft had the highest percentage of environment related mishaps (36%), half of which were pitching deck accidents (18%). Furthermore, pitching deck conditions were found to be related to two accident types, hard landings and undershoots, which accounted for 93% of all landing accidents. Pilot/aircraft height tracking responses under different levels of deck pitch were analyzed and results indicate that deck motion in excess of four feet may result in a 180 deg phase relation between deck pitch and pilot height tracking for certain aircraft. Synchronized records of deck motion and pilot aircraft height tracking during final approach to night carrier landing deck chasing phenomenon and provide graphic evidence of the consequences of 180 deg phase lags, especially for high accident risk aircraft. Author

**N71-20370#** School of Aerospace Medicine, Brooks AFB, Tex. Environmental Systems Div.

**EFFECT OF ACUTE AND CHRONIC EXPOSURE TO 21 mm Hg AMBIENT P SUB CO2 ON EXERCISE RESPONSE OF NORMAL MAN**

R. D. Sinclair, J. M. Clark and B. E. Welch *In AGARD Adaptation and Acclimatization in Aerospace Med.* Mar 1971 9 p refs (See N71-20351 09-04)  
Avail NTIS

Physiological responses to the interacting stresses of exercise and hypercapnia were studied in 4 young male subjects who were well trained and in excellent physical condition. The subjects performed light, intermediate and heavy exercise on a bicycle ergometer while breathing air and during acute (15-30 minutes) and chronic (15-20 days) exposure to an ambient P sub CO2 of 21 mm Hg. Simultaneous measurements of V sub E, V sub O2, V sub CO2, pulse rate, rectal temperature, and arterial P sub O2, P sub CO2 and pH were made at rest and from the 12th-15th minute of steady state exercise in the supine P sub O2 position. Increases in V sub E, V sub O2 and V sub CO2 were linear in response to increasing work load for all experimental conditions, but the average magnitudes of these parameters at similar work loads were essentially equal in acute and chronic hypercapnia. At each work load average V sub E was higher and average V sub CO2 was lower in hypercapnia than the corresponding values in air. Average V sub O2 and pulse rate varied little for the same work load in the different experimental conditions. The differences between mean arterial P sub CO2 during acute and chronic hypercapnia and arterial P sub CO2 during air breathing increased progressively with increasing work load. Decreases in arterial pH from resting control values were also progressive with increasing work load, but were similar in magnitude for the three experimental conditions owing to differences in metabolic acidosis. Author

**N71-20371#** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.

**VOLITIONAL CONTROL OF VISUAL ACCOMMODATION**

Robert J. Randle *In AGARD Adaptation and Acclimatization in Aerospace Med.* Mar 1971 13 p refs (See N71-20351 09-01)  
(NASA TM X 66955) Avail NTIS CSCL 06P

Research was conducted in an attempt to show that volitional control is possible in most individuals when feedback is provided which indicates to the subject his present accommodation level. The feedback was provided by modulating an audio oscillator with the output of a servo-controlled infra-red optometer which continuously

monitored the refractive state of the subject's eye. Six young males with normal vision were trained to control their accommodation first using a tone and then without it. A specific task they learned was to accommodate toward 0 diopters when a 3-diopter checkerboard target was extinguished and they viewed a dark empty field. Their performance was compared against six untrained subjects on two dark empty field test tasks. The tasks were (1) to maintain infinity focus while viewing a dark empty field for 3 minutes and (2) to go to infinity focus from a 3-diopter target when it was extinguished and a dark field ensued during a 3 minute period. A statistical analysis of the results showed that the trained group made significant reductions in their dark field myopia under these conditions, but the untrained subjects did not. Author

**N72-24058#** Advisory Group for Aerospace Research and Development, Paris (France)  
**AEROMEDICAL HANDBOOK FOR AIRCREW**  
 T. G. Dobbie. Mar 1972. 226 p.  
 (AGARD-AG-154) Avail NTIS HC \$13.50

An aeromedical handbook, designed to provide information on the various aspects of aviation medicine that affect aircrew tasks, is presented. Data cover mental and physical health, effects of noise, survival measures, high altitude breathing, preventive medicine, and various other protective measures necessary for a safe flight. E.H.W.

**N72-25031#** Advisory Group for Aerospace Research and Development, Paris (France)  
**THE DISORIENTATION INCIDENT, PART 1**  
 A. J. Benson, ed. (Royal Air Force Inst. of Aviation Med.) Mar 1972. 134 p. refs. Presented at Aerospace Med Panel Specialist Meeting, Luchon, France, 28 Sep 1971.  
 (AGARD-CP-95-Pt. 1) Avail NTIS HC \$8.75

The proceedings of a conference on spatial disorientation are presented. The subjects discussed are (1) description and analysis of disorientation incidents, (2) orientation error accidents, (3) training procedures, and (4) laboratory studies. The presentations were given in 16 reports. The principal findings and recommendations are summarized in a technical evaluation report. For individual titles, see N72-25032 through N72-25047.

**N72-25032#** San Jose State Coll., Calif.  
**DISORIENTATION INCIDENTS REPORT BY MILITARY PILOTS ACROSS 14 YEARS OF FLIGHT**  
 Brant Clark. In AGARD The Disorientation Incident, Part 1. Mar 1972. 7 p. refs. (See N72-25031 16-04)  
 (Grant NGL-05-046-002)  
 (NASA-CR-126786) Avail NTIS HC \$3.00 CSCL 065

The historical background of spatial disorientation problems among flying personnel is discussed. Recent incidents involving disorientation in flight were compared with incidents reported 14 years earlier. The incidents were very similar for various types of aircraft. The findings suggest that disorientation is currently experienced in a wide variety of flight operations and will continue to be experienced by flying personnel as an uncorrectable flight hazard. Author

**N72-25033#** Royal Air Force, Farnborough (England)  
**A REVIEW OF UNITED KINGDOM (RAF AND ARMY) STATISTICS ON SPATIAL DISORIENTATION IN FLIGHT 1960-1970**  
 R. G. Lofting. In AGARD The Disorientation Incident, Part 1. Mar 1972. 5 p. (See N72-25031 16-04)  
 Avail NTIS HC \$8.75

An analysis of spatial disorientation incidents among pilots of the Royal Air Force is presented. Subjects discussed are (1) disorientation statistics, (2) aircraft types involved in disorientation occurrences, (3) classification of disorientation accidents, (4) classification of disorientation occurrences, and (5) relevant aircraft design features leading to disorientation. Author

**N72-25034#** Naval Aerospace Medical Research Lab., Pensacola, Fla.

#### ORIENTATION ERROR ACCIDENTS IN ARMY AVIATION AIRCRAFT

V. Carroll Hixson, Jorma I. Niven, and Emil Spezia. (Army Board for Aviation Accident Res.) In AGARD The Disorientation Incident, Part 1. Mar 1972. 16 p. refs. (See N72-25031 16-04)

Avail NTIS HC \$8.75

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Board for Aviation Accident Research, and the Naval Aerospace Medical Research Laboratory. The first step was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective of the program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Army aviation flight operations beginning with July 1966. Incidence and cost data are presented for all Army aviation major and minor orientation-error accidents detected in the search of the accident files for the period July 1966 to July 1967. Separate and totaled statistical data are provided for fixed wing and rotary wing aircraft as well as for accidents occurring in Vietnam and those occurring elsewhere. Author

**N72-25035#** Bureau of Medicine and Surgery, Washington, D.C.

#### DISORIENTATION, FACT AND FANCY

Paul E. Tyler and Paul A. Furr. In AGARD The Disorientation Incident, Part 1. Mar 1972. 6 p. refs. (See N72-25031 16-04)  
 Avail NTIS HC \$8.75

The experiences of 2,000 naval aviators with disorientation during various flight conditions are presented. An analysis of all naval flight accidents for calendar year 1969 in which a disorientation incident contributed to the accident was made. It is shown that the majority of accidents coded as related to disorientation were erroneously coded. It was concluded that approximately 96 percent of aviators experience disorientation at some time, but that this disorientation contributes to a very small percentage of the accidents. Author

**N72-25036#** Naval Air Station, Norfolk, Va. Safety Center  
**PSYCHOPHYSIOLOGICAL AND ENVIRONMENTAL FACTORS AFFECTING DISORIENTATIONS IN NAVAL AIRCRAFT ACCIDENTS**

Earl H. Nincw, William F. Cunningham, and Frederick A. Radcliffe. In AGARD The Disorientation Incident, Part 1. Mar 1972. 4 p. refs. (See N72-25031 16-04)  
 Avail NTIS HC \$8.75

Psychophysiological and environmental factors, 12 in number, which most affect disorientation related mishaps are presented. These factors are listed in order of number of occurrence and it is indicated that often multiple factors are coded in conjunction with disorientation. Examples of disorientation related mishaps are presented to demonstrate psychophysiological and environmental factor involvement. A graph comparing attack and fighter pilot flight exposure to disorientation mishaps is charted to demonstrate the effect of experience upon control of disorientation. The chart indicates that flight experience does play a role in deterring of disorientation mishaps. Author

**N72-25037#** Naval Air Development Center, Johnsville, Pa.  
 Crew Systems Dept.  
**DISORIENTING EFFECTS OF AIRCRAFT CATAPULT LAUNCHINGS**

Malcolm M. Cohen, Richard J. Crosbie, and Laurence H. Blackburn. In AGARD The Disorientation Incident, Part 1. Mar 1972. 6 p. refs. (See N72-25031 16-04)  
 Avail NTIS HC \$8.75

A human centrifuge facility was used to simulate the acceleration profiles encountered in aircraft catapult launchings. Twelve subjects attempted to keep a continuously moving target at subjective eye level before, during, and after exposure to simulated catapult launch accelerations. Results demonstrated that subjective eye level was changed by exposure to the accelerative forces. The change in subjective eye level persisted, in some cases, for as long as three minutes after the simulated launch sequence was completed. The results are discussed in terms of the effects of rotated acceleration vectors on human spatial orientation, and the data are related to certain types of aircraft losses that have been reported following catapult launchings at night. Author

**N72-25038#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio  
**EFFECTS OF ACOUSTIC STIMULI ON THE VESTIBULAR SYSTEM**

C Stanley Harris. In AGARD The Disorientation Incident, Part 1 Mar 1972. 11 p. refs (See N72-25031 16-04)  
 (AMRL-TR-71-58) Avail NTIS HC \$8 75

The effects of noise intensity on the human vestibular system with resultant disorientation, nausea, and dizziness are discussed. The response of human subjects to acoustic stimuli was measured using nystagmography, vertical perception, and a rail test of human equilibrium. Decrements in performance of 20 to 35 percent were obtained in high intensity noise of 140 decibels even when subjects wore ear protectors. Sound levels as low as 100 decibels were found to produce an adverse effect on task performance. It was also determined that noise levels affect human equilibrium at levels below those which will damage hearing. Author

**N72-25039#** Institute of Aviation Medicine, Fuerstentfeldbruck (West Germany)

**ALCOHOL INDUCED POSTROTATORY FIXATIONAL NYSTAGMUS, A TRAINING FILM ON A SIMPLE METHOD OF DETECTING SLIGHT ALCOHOLIC INTOXICATIONS IN PILOTS**

G Froehlich. In AGARD The Disorientation Incident, Part 1 Mar 1972. 3 p. refs (See N72-25031 16-04)  
 Avail NTIS HC \$8 75

A method for detecting moderate alcoholic intoxication in human subjects is presented. The method is based on observation of inability of intoxicated subject to suppress postrotatory fixational nystagmus. The subject, in a standing position, is turned around his vertical axis five times within ten seconds with his eyes open in a normally illuminated room. When the subject is stopped and asked to fix his vision on the examiner's finger held about 25 centimeters in front of his eyes, the intoxicated subject will be unable to fixate. The method involved was demonstrated by a motion picture. Author

**N72-25040#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio

**ANALYSIS OF THE VESTIBULO-OCULAR COUNTERROLL REFLEX IN PRIMATES**

A M Junker, C R Replogle, K A Smiles, R D Brown, and R H Wheeler (AF Inst of Technol). In AGARD The Disorientation Incident, Part 1 Mar 1972. 10 p. refs (See N72-25031 16-04)  
 (AMRL-TR-71-59) Avail NTIS HC \$8 75

The vestibulo-ocular reflex manifest by counterroll was used to determine the response dynamics of the vestibular system and alterations in these dynamics subsequent to +Gx acceleration exposure. Six rhesus monkeys were tested before and after acceleration exposure to determine if significant changes had occurred in the vestibulo-ocular counterroll reflex. The tests consisted of constant speed rotation, pendular oscillations and multiple sine wave oscillations about the subject's cyclopean axis. Ocular counterroll was recorded using a linear resolver mechanically fixed to the monkey's eyeball. There is no significant decrease in the system gain with inputs up to 1 Hz. The observed phase lag can be accounted for by a time delay of

approximately 0.2 seconds, and there is no significant response alteration caused by acceleration loading up to 75 +Gx. Author

**N72-25041#** Advisory Group for Aerospace Research and Development, Paris (France)

**TWO SPECIFIC KINDS OF DISORIENTATION INCIDENTS: JET UPSET AND GIANT HAND**

R Malcolm and K E Money. In its The Disorientation Incident, Part 1 Mar 1972. 4 p. refs (See N72-25031 16-04)  
 Avail NTIS HC \$8 75

In certain circumstances (instrument flying conditions and severe turbulence), an inappropriate pilot input to aircraft controls leads to a dangerous nose down attitude of the aircraft. There have been something in excess of 26 of these jet upsets. In similar circumstances, there have been a few reports of what can be called the Giant Hand phenomenon, in which the pilot reports that the aircraft controls are forced into an extreme position and held there as if by a giant hand. Precipitating circumstances and underlying mechanisms of these two kinds of incidents are discussed, and some unpublished experimental observations are presented. Author

**N72-25042#** Royal Air Force Inst of Aviation Medicine, Farnborough (England)

**SPATIAL DISORIENTATION AND THE BREAK-OFF PHENOMENA**

A J Benson. In AGARD The Disorientation Incident, Part 1 Mar 1972. 11 p. refs (See N72-25031 16-04)  
 Avail NTIS HC \$8 75

Reports of aircraft pilots concerning occurrence of disorientation with subsequent feelings of unreality and detachment are analyzed. It was determined that the reactions occurred during monotonous phases of flight in conditions where external visual orientation cues were restricted. Evidence is presented which suggests the spatial disorientation occurring as a concomitant of break-off was caused by minor degrees of vestibular asymmetry. The high incidence of anxiety reactions supports the view that in susceptible individuals break-off can be both a precipitant and a manifestation of anxiety neurosis. Author

**N72-25043#** Naval Submarine Medical Center, Groton, Conn Research Lab

**VERTIGO IN DIVERS**

C F Gell. In AGARD The Disorientation Incident, Part 1 Mar 1972. 4 p. refs (See N72-25031 16-04)  
 Avail NTIS HC \$8 75

The occurrence of vertigo in hyperbaric atmospheres and with underwater divers is discussed. Theories are presented to explain the etiology of these events. Some of the theories are: (1) barotrauma, (2) damage from the formation of bubbles, (3) hyperemia and hemorrhage, (4) unusual displacement of the stapes, (5) caloric stimulation, (6) slow movement of the ear drum and ossicles causing eddy currents, (7) performance of the valseva maneuver, and (8) disturbed labyrinthian function. Author

**N72-25044#** Naval Aerospace Medical Research Lab., Pensacola, Fla

**THEORY OF DEVELOPMENT OF REACTIONS TO WHOLE BODY MOTION CONSIDERED IN RELATION TO SELECTION, ASSIGNMENT, AND TRAINING OF FLIGHT PERSONNEL**

Fred E Gundry, Jr. In AGARD The Disorientation Incident, Part 1 Mar 1972. 17 p. refs (See N72-25031 16-04)  
 Avail NTIS HC \$8 75

A speculative theory, dealing with the development of reactions to whole body motion, is outlined. Functional aspects of reactions at several stages of maturation are considered in relation to conditioning mechanisms, which are, in turn, related to individual differences in development of motion reactivity, personality, and cognitive function. Unnatural feedback resulting from passive motion is discussed in relation to different control

tasks performed in different job assignments and in relation to individual differences in reactions to motion. Adaptation to the unnatural whole-body movement of flight is considered in this context and in relation to experiments illustrating that substantial changes in reactions to motion can be accomplished through habituation. Aviator selection tests, personality tests, flight aptitude tests, and several categories of training are considered in relation to the theoretical constructs. Author

**N72-25045#** Civil Aeromedical Inst., Oklahoma City, Okla. Psychology Lab

**PRACTICAL TECHNIQUES FOR DISORIENTATION FAMILIARIZATION AND THE INFLUENCE OF VISUAL REFERENCE AND ALCOHOL ON DISORIENTATION-RELATED RESPONSES**

William E. Collins. In AGARD. The Disorientation Incident, Part 1. Mar. 1972. 10 p. refs (See N72-25031 16-04). Avail. NTIS

Techniques and procedures for providing on-the-ground familiarization of aviation personnel with the effects of disorientation are discussed. The procedures are relatively inexpensive, effective for both participants and observers, and are readily accepted by aviators as pertinent to the aviation situation. The extent to which disorientation is affected by the type of visual information available to the pilot is examined under normal conditions and when alcohol is involved. Ways of demonstrating the deleterious effects of alcohol are described. Author

**N72-25046#** Royal Air Force Central Medical Establishment, London (England).

**THE DISORIENTATION ACCIDENT: PHILOSOPHY OF INSTRUMENT FLYING TRAINING**

T. G. Dobie. In AGARD. The Disorientation Incident, Part 1. Mar. 1972. 4 p. refs (See N72-25031 16-04). Avail. NTIS HC \$8.75

Patterns of disorientation occurrences in the United Kingdom RAF and Army for the period 1960-1970 are examined in order to formulate possible explanations and recommendations concerning, in particular, the philosophy of instrument flight training. The aircraft types most commonly involved and the circumstances confirm the likelihood of sensory incongruity being a contributory factor in the majority of cases. The underlying differences between primary and secondary disorientation are discussed. The predominant emphasis both in aeromedical indoctrination and instrument flying practice is concerned with preventing primary spatial disorientation, but insufficient effort is made towards ensuring that primary disorientation when it occurs, does not develop into the dangerous secondary stage. The various methods of simulation of instrument flying are examined. Author

**N72-25047#** Advisory Group for Aerospace Research and Development, Paris (France).

**CLINICAL EVALUATION AND TREATMENT OF DISORIENTATION IN AIRCREW**

P. J. O'Connor. In its The Disorientation Incident, Part 1. Mar. 1972. 6 p. (See N72-25031 16-04). Avail. NTIS HC \$8.75

The clinical evaluation and medical treatment of disorientation problems in flying personnel are discussed. It was determined that disorientation occurs most frequently in ages between 30 and 50. The symptoms were divided into (1) increased sensory input, (2) decreased sensory input, and (3) disturbed central thought processes. Treatment was by explanation and reassurance with the addition of rehabilitation flying and treatment of associated psychiatric disorders. Of the 90 cases treated, 54 returned to full flying duty. Author

**N72-25048#** Advisory Group for Aerospace Research and Development, Paris (France).

**IMPROVED AND SIMPLIFIED METHODS FOR THE CLINICAL EVALUATION OF AIRCREW. PART 2**

Heinz S. Fuchs, ed. (AF Hospital Inspection System, West Germany) Mar. 1972. 81 p. refs. Mostly in ENGLISH, partly in FRENCH. Presented at the Aerospace Med. Panel Specialist Meeting, Luchon, France, 29-30 Sep. 1971. (AGARD-CP-95-Pt-2) Avail. NTIS HC \$6.25

Practical aeromedical requirements are discussed in the areas of cardiorespiratory assessment, anthropometric methods, biochemical analyses, X-ray examinations, and special visual investigation methods. For individuals: titles, see N72-25049 through N72-25060.

**N72-25049#** Beech Army Hospital, Fort Wolters, Tex. **MEDICAL ELIMINATION OF STUDENTS UNDERGOING PRIMARY FLIGHT TRAINING**

Guthrie L. Turner, Jr. and Eric E. Lundstrom. In AGARD. Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 5 p. refs (See N72-25048 16-04). Avail. NTIS HC \$6.25

A group of 5,278 student aviators were processed for primary helicopter training. All had undergone the initial Class 1 or 1A flight physical examination for flying and were found qualified. Students eliminated during calendar year 1970 from all causes totaled 1,410. Of this number 168 were eliminated for medical causes. Eye defects, ear, nose and throat defects, and neuropsychiatric abnormalities accounted for 53.8% of the medical eliminations. Of the 168 student aviators eliminated, 87 had medical defects that were probably detectable on the initial flight physical. Author

**N72-25050#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

**WHAT IS THE MEANING OF THE MASTER-STEP-TEST IN EXAMINATIONS TO DETERMINE THE FITNESS FOR MILITARY FLYING DUTY**

H. W. Kirchheft and A. Dietz. In AGARD. Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 3 p. (See N72-25048 16-04). Avail. NTIS HC \$6.25

Long term examinations by means of an ECG were conducted on approximately 1000 pilots between 18 and 50 years of age. For the period of the past 14 years, at least 8 ECG's were obtained for each pilot. The examinations revealed the following results: (1) Abnormal or conspicuous ECG alterations are found to a small extent in tests at rest and in master tests. (2) The number of conspicuous ECG findings increases with age. It became evident that special examinations, such as ergometer or hypoxia ECG, more frequently indicate abnormal ECG alterations than the routine procedures. Use of the master test is recommended only in routine examinations from the 35th year of age on. Author

**N72-25051#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

**USE OF LONGTERM ECG IN AVIATION MEDICINE**

A. Dietz and H. W. Kirchheft. In AGARD. Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 6 p. refs (See N72-25048 16-04). Avail. NTIS HC \$6.25

A one-channel portable tape recording system for long term ECG recording is described. The possibilities of application of such a system in the examination and assessment of flying personnel is considered. Topics discussed include: (1) supplementation of ECG diagnostics in examinations to determine fitness for military flying duty, (2) longitudinal observations for scientific clarification of certain ECG alterations, (3) inflight ECG examinations, and (4) heart rate registration during special examinations in aviation psychology, and training effects on heart rate. Author

**N72-25052#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

**THE AUTOMATIC ANALYSIS OF THE ECG AT REST, DURING AND AFTER EXERCISE WITH TWO DIFFERENT COMPUTER SYSTEMS**

J. Zipfel, J. D. Meyer-Erkelenz, C. V. Kirschbaum, and H. W. Kirchhoff. *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 5 p. (See N72-25048 16-04)  
 Avail. NTIS HC \$6.25

The quality of various lead systems and computer programs for ECG diagnosis is considered. For the evaluation of the standard leads, the Minnesota system can be used. The program of Arvedson was used for the Frank system, which is particularly suitable for computer. The ECG was recorded at rest and during exercise to detect the beginning of coronary artery disease. The quantified ergometer work load was used as exercise. Attention was directed towards the evaluation of ST-T changes. The results were compared with the diagnosis of a cardiology team for the two computers. It is concluded that at rest and in the postexercise period, the use of both computer systems is justified.  
 Author

**N72-25053#** School of Aerospace Medicine, Brooks AFB, Tex. **EXTENDED ELECTROCARDIOGRAPHIC MONITORING WITH EMPHASIS ON COMPUTER ANALYSIS OF THE RECORDS**

William H. Walter, III, Eric D. Grassman, Edward J. Engelken, and Malcolm C. Lancaster. *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 5 p. refs. (See N72-25048 16-04)  
 Avail. NTIS HC \$6.25

The use of continuous 6 to 8 hour tape-recorded electrocardiograms in the evaluation of patients with known or suspected cardiac disorders proved to be of value. All of the present commercially available equipment requires that a physician personally review each 6 to 8 hour tape. These tapes may be scanned at 36 to 60 times real time, and suspicious portions may be reproduced in equivalent real time. In an effort to accurately detect, count, and classify atypical ventricular depolarization complexes, an analog computer program was developed.  
 Author

**N72-25054#** Royal Air Force Hospital, Wegberg (West Germany). **PROBLEMS IN THE CLINICAL ASSESSMENT OF RAISED ARTERIAL BLOOD PRESSURE IN AIRCREW**

J. N. C. Cooke. *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 3 p. refs. (See N72-25048 16-04)  
 Avail. NTIS HC \$6.25

The further assessment of apparently raised blood pressure levels found on routine examination of aircrew members is considered. The initial problem is posed by difficulties in establishing definite limits of normalcy and in fixing any level of blood pressure that divides health from disease. In the Royal Air Force, a consultant physician makes an initial clinical assessment and decides if there is a requirement for detailed investigation. This investigation consists of a standardized comprehensive search for possible causes for a rise in blood pressure and for associated pathological conditions. After this investigation a number of subjects remain whose fitness for further flying must be judged upon their blood pressure alone. These figures are subject to great variability, compounded by known factors of anxiety, tension, observer error, and environmental influences. Some of these problems might be reduced by repeated recordings under standardized conditions and the use of automatic cuff recorders in the hope that comparisons over varying time intervals may show up clear trends of improvement or deterioration in an individual. Final disposal still depends largely on the statistical evidence for increased mortality and morbidity associated with raised blood pressure levels and the resultant need to institute treatment.  
 Author

**N72-25055#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

**A SIMPLIFIED AND IMPROVED METHOD FOR OPERATIONAL ANTHROPOMETRIC PROGRAMMES**

H. J. Grunhofer. *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 8 p.  
 Avail. NTIS HC \$6.25

The operational significance of anthropometric data is demonstrated by an example of consequences following the introduction of an ejection seat in an aircraft. Several simplified measuring devices and techniques are discussed. A device for the application of anthropometric data and for medical re-evaluation of pilots with possible functional impairments is discussed.  
 Author

**N72-25056#** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).

**RADIOLOGICAL EXAMINATION OF THE SPINE AND THE COMBAT PILOT'S CAPABILITY FOR DUTY [EXAMEN RADIOLOGIQUE DU RACHIS ET APTITUDE A L'EMPLOI DE PILOTE DE COMBAT]**

R. P. Delahaye, G. Gueffier, and P. J. Metges. *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 10 p. refs. *In* FRENCH. (See N72-25048 16-04)  
 Avail. NTIS HC \$6.25

The radiological examination of the spine during entrance fitness examinations of flying personnel is discussed. The limiting scoliotic angle for combat flight was determined to be 10 degrees, beyond which there is danger of injury in the case of ejection from the aircraft.  
 Transl. by K.P.D.

**N72-25057#** National Aeronautics and Space Administration, Washington, D.C.

**A SIMPLIFIED SPACE TECHNOLOGY METHOD FOR CLINICAL AIRCREW MEASUREMENT OF FUNCTIONAL RESPIRATORY VALUES**

Walton L. Jones and B. M. Bushman (Parker-Elmer Corp., Pomona, Calif.). *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 11 p. (See N72-25048 16-04)  
 (NASA-TM-X-68370) Avail. NTIS HC \$3.00. USCL 06E

A versatile, rapid, reliable respiratory gas analyzer based on mass spectrometer principles was developed for air crew pulmonary function measurement. The instrument can provide a continuous and simultaneous analysis of up to eight gases useful in pulmonary function evaluation. The principal gases include oxygen, carbon dioxide, nitrogen, and water vapor. The instrument is suited to air crew and space cabin applications because (1) The quantity of gas diverted to the mass spectrometer is a negligible fraction of the expired gas. (2) The time response of the mass spectrometer is fast relative to the breath cycle time. (3) The mass spectrometer is capable of accurate partial pressure measurements. (4) The size, weight, and power requirements are compatible with most in-flight applications. (5) Simplicity and reliability of operation are stressed.  
 Author

**N72-25058#** Royal Air Force, Farnborough (England). Central Medical Establishment.

**IMPROVED METHODS OF CLINICAL ELECTRODIAGNOSIS IN PROGNOSIS OF LOWER MOTOR NEURONE LESIONS**

C. B. Wynn-Parry. *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 4 p. refs. (See N72-25048 16-04)

Avail. NTIS HC \$6.25

Techniques in electromyography are discussed in connection with the diagnosis of lower motor neurons lesions. Various lesions and their symptoms are considered.  
 K.P.D.

**N72-25059#** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).

**INTEREST IN MEASURING RESISTANCE TO VERTIGO AMONG FLYING PERSONNEL [INTERET DE LA MESURE DE LA RESISTANCE A L'EPLOUISSEMENT CHEZ LES MEMBRES DU PERSONNEL NAVIGANT]**

J. P. Chevaleraud and G. Perdiel. *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2. Mar. 1972. 3 p. *In* FRENCH. (See N72-25048 16-04)  
 Avail. NTIS HC \$6.25

A simple method is presented which permits the evaluation

of aptitude for regaining visual function while being subjected to vertigo. The orientation of the subject and authorization for revocation of flight activities when an ocular affection is involved are considered. Transl. by K.P.D.

**N72-25060#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**ALCOHOL INDUCED POSTROTATORY FIXATIONAL NYSTAGMUS, A TRAINING FILM ON A SIMPLE METHOD OF DETECTING SLIGHT ALCOHOLIC INTOXICATIONS IN PILOTS**

G. Froehlich /In AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2 Mar. 1972 11 p refs (See N72-25045 16-04)

Avail NTIS HC \$8.25

A film showing the practical procedure and its nystagmographical correlates is discussed. With this test, the flight surgeon has at his disposal a reliable and simple method to detect and thus eliminate from duty flying pilots in an acute state of alcohol intoxication or with a marked hangover from the night before. Author

**N72-26045#** Advisory Group for Aerospace Research and Development, Paris (France)

**SPECIAL BIOPHYSICAL PROBLEMS IN AEROSPACE MEDICINE, PART 3**

A. M. Pfister, ed. Mar. 1972 126 p refs. Partly in ENGLISH and FRENCH. Presented at Aerospace Med Panel Specialist Meeting, Luchon, France, 30 Sep - 1 Oct. 1971 (AGARD-CP-95-Pt-3) Avail NTIS HC \$8.50

A biophysical approach to solving the problems faced by man when exposed to cosmic rays, electromagnetic waves, magnetic fields, and laser radiation is summarized. For individual titles, see N72-26046 through N72-26057.

**N72-26046#** Kiel Univ. (West Germany)

**PRESENT KNOWLEDGE OF COSMIC RAYS**

O. C. Allkofer /In AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 14 p refs (See N72-26045 17-04)

Avail NTIS HC \$8.50

The main features of cosmic radiation are outlined as far as they are of interest concerning radiation hazards in SST and manned space flights. The properties of the galactic and solar component and of the radiation belts are characterized. The interactions of the primary particles with the atmosphere and the earth's magnetic field are illustrated and figures are given for the altitude and latitude dependence. Finally, the modulation effects of the galactic component due to the solar influence are discussed. Author

**N72-26047#** Atomic Weapons Research Establishment, Aldermaston (England) Radiation Measurements Section

**ACTIVE DOSIMETRY OF COSMIC RADIATION**

E. W. Fuller /In AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 11 p refs (See N72-26045 17-04)

Avail NTIS HC \$8.50

The role assumed for active dosimetry in manned space missions and high altitude flight is to enable the exposure received during flight to be controlled by on-board monitoring. The radiation environment and the need for active dosimetry in the two circumstances are reviewed and then the instrumentation available and under development for this application is described. Methods of calibrating such instrumentation are also considered. It is concluded that satisfactory instruments for both applications are presently available but that there is a need for continuing development of more compact systems for high altitude aircraft. Author

**N72-26048#** Centre de Recherches Nucleaires, Strasbourg (France) Lab de Physique Corpusculaire

**PASSIVE DOSIMETRY OF COSMIC RADIATION [DOSIMETRIE PASSIVE DU RAYONNEMENT COSMIQUE]**

R. Kaiser /In AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 9 p In FRENCH (See N72-26045 17-04)

Avail NTIS HC \$8.50

The use of passive dosimetry to study the biological effects of cosmic radiation is discussed. The problems and functions of using such equipment are also examined. Experimental dose rates were calculated and compared to measured ones. Results are given in tables. Transl. by E.H.W.

**N72-26049#** Centre d'Enseignement et de Recherches de Medecine Aeronautique, Paris (France)

**SOME CONSIDERATIONS ON THE DIFFICULTIES OF DOSIMETRIC EVALUATION AND COSMIC RADIATION INJURIES [QUELQUES CONSIDERATIONS SUR LES DIFFICULTES DE L'EVALUATION DOSIMETRIQUE ET LESIONNELLE DES RADIATIONS COSMIQUES]**

S. Despres, C. Nogues, and G. Deltour /In AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 6 p In FRENCH (See N72-26045 17-04)

Avail NTIS HC \$8.50

The difficulties encountered in the dosimetric evaluation of cosmic rays and their effect on living matter are reported. Data cover the effects of heavy ions on skin pigments, nervous tissue, human cells in culture, biological molecules, and microorganisms. Transl. by E.H.W.

**N72-26050#** Toulouse Univ. (France) Lab. de Biologie Medicale

**EVIDENCE ON THE EFFECT OF NATURAL IONIZING RADIATION ON BIOLOGICAL STIMULATION [MISE EN EVIDENCE D'UN EFFET BIOLOGIQUE DE STIMULATION DES RADIATIONS IONISANTES NATURELLES]**

H. Planel, J. P. Soleilhavoup, R. Tixador, M. C. Gress, and F. Croute /In AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 12 p refs in FRENCH (See N72-26045 17-04)

Avail NTIS HC \$8.50

The effects of radioprotection and very weak irradiations on unicellular organism multiplication and embryonic development of *Drosophila melanogaster* are studied. Results show that in unicellular organisms, irradiation prolonged the cellular cycle and reduced multiplication. When the organisms were returned to a radioprotected environment, their multiplication and cellular cycles returned to normal. In the fruit fly, radiation exposure caused prolonged embryonic and larvae development. Transl. by E.H.W.

**N72-26051#** National Aeronautics and Space Administration Manned Spacecraft Center, Houston, Tex

**VISUAL PHENOMENA INDUCED BY COSMIC RAYS AND ACCELERATED PARTICLES**

Cornelius A. Tobias, Thomas F. Budinger, John T. Lenth, Abdel-Megid Mamoon, and Philip Chapman /In A. 13D Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 12 p refs. Prepared in cooperation with Calif. Univ., Berkeley (See N72-26045 17-04)

(NASA-TM-X-68460) Avail NTIS HC \$3.00 CSCL 06R

Experiments, conducted at cyclotrons together with observations by Apollo astronauts, suggest with little doubt that cosmic nuclei interacting with the visual apparatus cause the phenomenon of light flashes seen on translunar and transearth coast over the past four Apollo missions. Other experiments with high and low energy neutrons and a helium ion beam suggest that slow protons and helium ions with a stopping power greater than 10 to the 8th power e.v./gram sq cm can cause the phenomenon in the dark adapted eye. It was demonstrated that charged particles induced by neutrons and helium ions can stimulate the visual apparatus. Some approaches to understanding the long term mission effects of galactic cosmic nuclei interacting with man and his nervous system are outlined. Author

**N72-26052#** Centre de Recherches Nucleaires, Strasbourg (France) Lab de Physique Corpusculaire



**FIRST RESULTS OF PASSIVE DOSIMETRIC COSMIC RADIATION EFFECTS ONBOARD A PROTOTYPE OF THE CONCORDE 001 SUPERSONIC TRANSPORT [PREMIERS RESULTATS DE LA DOSIMETRIE PASSIVE DU RAYONNEMENT COSMIQUE EFFECTURE A BORD DU PROTOTYPE DE L'AVION DE TRANSPORT SUPERSONIQUE CONCORDE 001]**

R Kaiser, A M Pfister, and R P Delahave. In AGARD Spec Biophys Probl in Aerospace Med. Pt 3 Mar 1972 10 p refs In FRENCH (See N72-26045 17-04)  
Avail NTIS HC \$8 50

After a description of the characteristics of passive dosimetry carried out with the aid of equipment installed onboard a French prototype of the Concorde supersonic transport aircraft, the methods used to calculate the cosmic radiation dose rates and the results obtained are given. A preliminary interpretation of dose rates was made and compared to those obtained in an English prototype. The results from this comparison show the dose rates are in agreement.

Transl by E H W

**N72-26053# Service de Sante des Armees, Toulon (France) BIOLOGICAL EFFECTS OF UHF ELECTROMAGNETIC RADIATION [EFFETS BIOLOGIQUES DES RAYONNEMENTS ELECTROMAGNETIQUES UHF (RADARS)]**

R Joly and B Servantie. In AGARD Spec Biophys Probl in Aerospace Med. Pt 3 Mar 1972 14 p refs In FRENCH (See N72-26045 17-04)  
Avail NTIS HC \$8 50

Very high frequency radiation effects, emitted by radar equipment, on the human organism are investigated. The physiological and physiopathological aspects are outlined. Data also cover pulse duration, penetrative power, energy density and exposure time.

Transl by E H W

**N72-26054# Bureau of Medicine and Surgery, Washington, D C**

**THE US NAVY'S PROGRAM IN NONIONIZING RADIATION**  
Paul E Tyler. In AGARD Spec Biophys Probl in Aerospace Med. Pt 3 Mar 1972 4 p refs (See N72-26045 17-04)  
Avail NTIS HC \$8 50

The extent of dependence of military forces upon electromagnetic radiation emitters for their day-to-day operations is discussed. The current concepts and safety standards of the Eastern European countries are reviewed briefly. The current Navy program in the area of nonionizing radiation is presented. Three major approaches are emphasized: (1) basic research, (2) exploratory research, and (3) epidemiological surveys. The lack of adequate dosimetric instrumentation is discussed and the current program to develop instrumentation is presented.

Author

**N72-26055\*# Naval Aerospace Medical Research Lab Pensacola, Fla**

**MAGNETIC FIELDS AND MAN: WHERE DO WE STAND TODAY?**

Dietrich E Beischer and Vernon R Renc. In AGARD Spec Biophys Probl in Aerospace Med. Pt 3 Mar 1972 9 p refs Sponsored in part by NASA (See N72-26045 17-04)  
(NASA-CR-127049) Avail NTIS HC \$3 00 CSCL 06R

An assessment is made of the effects of very low and very high magnetic fields on man. In preparation for the Apollo flights, magnetic fields of 50 gamma were generated in the laboratory by two different methods. Human volunteers were tested with a comprehensive battery of physiological and psychological tests during and after continuous exposure for various time periods. No significant difference due to the low field was found for exposure periods of up to 10 days. Technological advancements in power generation, antisubmarine warfare, and energy storage and transmission expose man to magnetic fields many orders of magnitude higher than those heretofore encountered. The only available information relevant to these conditions is based upon occasional observations in high energy physics laboratories and Soviet descriptions of clinical effects. Results of incidental human exposure and of

primates exposed to high fields indicate that, while actual survival is not threatened by such exposures, high fields can influence man to a degree sufficient to cause serious performance decrement.

Author

**N72-26056# Duke Univ., Durham, N C Dept of Ophthalmology LASER SAFETY AND HOW TO PROMOTE IT**

Myron L Wolbarsht. In AGARD Spec Biophys Probl in Aerospace Med. Pt 3 Mar 1972 6 p refs (See N72-26045 17-04)

(Contract N00014-67-A-0251-0011)

Avail NTIS HC \$8 50

The characteristics of lasers which may produce danger are briefly discussed with regard to the special characteristics of laser light and also the characteristics they share with other light sources. Types of personnel protection are considered as are regulations and safety programs in relation to the energy and power levels that are currently thought to be nonhazardous. The principles of hazard analysis are described in conjunction with their use at any particular safety level. Two of the programs carried on by the U S Navy Medical Department on laser safety are considered in detail. One deals with the functional decrement in visual acuity of monkeys by pulsed laser trains in the near infrared. The other is concerned with the determination of threshold levels for ocular injury by lasers in human volunteers.

Author

**N72-26057# Royal Air Force Inst of Aviation Medicine, Farnborough (England)**

**LASER SAFETY: SOME CONSIDERATIONS IN THE DESIGN OF A CODE OF PRACTICE**

R G Borland. In AGARD Spec Biophys Probl in Aerospace Med. Pt 3 Mar 1972 13 p refs (See N72-26045 17-04)  
Avail NTIS HC \$8 50

Military and industrial research on a safety code for the use of laser equipments is outlined. Data cover safe thresholds, methods for measuring these thresholds, and characteristics of the laser to be used. Special attention is given to retina damage in the operators.

E H W

**N73-17098# Advisory Group for Aerospace Research and Development, Paris (France)**

**AEROMEDICAL ASPECTS OF VIBRATION AND NOISE**

J C Guignard and P F King. Nov 1972 280 p refs (AGARDograph-151, AGARD-AG-151) Avail NTIS HC \$16 00

Effects of aerospace vibration and noise on man are considered. The special aeromedical problems of auditory perception and noise injuries in aircrew and ground support personnel are emphasized. For individual titles, see N73-17099 through N73-17101.

**N73-17099 Wright State Univ., Dayton, Ohio Dept. of Engineering VIBRATION**

J C Guignard. In AGARD Aeromed. Aspects of Vibration and Noise. Nov 1972 p 1-113 refs (For availability see N73-17098 08-04)

The nature of structure-borne vibration and its occurrence in aerospace operations are considered by mechanical and biological actions upon man, and by the criteria and principles of protecting man from its adverse effects.

Author

**N73-17100 Wright State Univ., Dayton, Ohio NOISE**

J C Guignard. In AGARD Aeromed. Aspects of Vibration and Noise. Nov 1972 p 114-203 refs (For availability see N73-17098 08-04)

Nature, measurement and occurrence of airborne noise in aerospace operations are considered by the biological effects on man. General criteria and principles of the protection of man from the adverse effects of noise on human well being and working efficiency are outlined.

Author

**N73-17101** Royal Air Force Central Medical Establishment, London (England).

**HEARING CONSERVATION IN AIRCREW AND GROUND SUPPORT PERSONNEL**

P. F. King. In AGARD Aeromed. Aspects of Vibration and Noise. Nov. 1972. p. 204-257. refs. (For availability see N73-17098 06-04)

The effects of noise on human hearing, both temporary and permanent, are reviewed and related to the working situations of members of aircrews and ground support personnel. Measures to be taken to prevent noise damage in the peripheral parts of the human hearing mechanism and to conserve hearing in personnel exposed to hazardous noise levels are outlined.

Author

**N73-17106#** Advisory Group for Aerospace Research and Development, Paris (France)

**SPECIAL ASPECTS OF AVIATION OCCUPATIONAL MEDICINE. CARDIOVASCULAR AND NERVOUS SYSTEM EFFECTS OF BROMOTRIFLUOROMETHANE**

K. C. Back (AMRL) and E. W. VanSice (AMRL). Nov. 1972. 20 p. refs.

(AGARD-R-599) Avail. NTIS HC \$300

The effects of three fluorocarbons of the haloalkane group, principally with bromotrifluoromethane, which have applications as effective fire extinguishing agents are studied. Animal experiments, performed to explore the mechanisms of the pharmacodynamic properties and to assess the toxic hazards associated with their use, are described. All three compounds have biological side effects and the report provides preliminary information, derived from animal experiments, on acceptable working concentrations for human exposure.

Author

**N73-19065#** Advisory Group for Aerospace Research and Development, Paris (France)

**COLOR VISION REQUIREMENTS IN DIFFERENT OPERATIONAL ROLES**

Nov. 1972. 83 p. refs. In ENGLISH, partly in FRENCH. Presented at AGARD Aerospace Med. Panel Specialist Meeting, Brussels, 30 May 1972.

(AGARD-CP-99) Avail. NTIS HC \$625

Proceedings are presented on the theoretical and practical aspects of color vision, the rationale of color vision requirements for air and ground crews, and color vision testing. The requirements for flying personnel of the armed forces for many nations are emphasized. For individual titles, see N73-19066 through N73-19076.

**N73-19066\*** Duku Univ., Durham, N.C. Dept. of Ophthalmology

**THEORETICAL ASPECTS OF COLOR VISION**

Myron L. Wolbarsht. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 10 p. refs. (For availability see N73-19065 10-04)

(Contract NAS9-11994)

The three color receptors of Young-Helmholtz and the opponent colors type of information processing postulated by Hering are both present in the human visual system. This mixture accounts for both the phenomena of color matching or hue discrimination and such perceptual quantities of color as the division of the spectrum into color bands. The functioning of the cells in the visual system, especially within the retina, and the relation of this function to color perception are discussed.

Author

**N73-19067** Institute of Aviation Medicine, Fuerstenfeldbruck (Wirt. Germany). Ophthalmological Branch

**PRACTICAL ASPECTS OF COLOR VISION AND ITS DISTURBANCE**

Dietrich Kuerschi. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 8 p. refs. (For availability see N73-19065 10-04)

A number of specialists of the German Air Force, except the flying personnel, were assessed to determine the extent of color vision required. It is shown that normal color vision is mandatory only for the activities of the telephone technician and the telephone

**N73-19068** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

**EXAMINATION OF CHROMATIC SENSE IN FRENCH AERIAL FORCES [L'EXAMEN DU SENS CHROMATIQUE DANS LES FORCES AERIENNES FRANCAISES]**

G. Perdriel and J. Chavalerand. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 5 p. In FRENCH. (For availability see N73-19065 10-04)

A procedure was developed to test the chromatic aptitude of dyschromatopsia victims who wanted positions as navigators or pilots in France. Security procedures using such personnel and a color signaling process to aid them in perceiving colors are discussed.

Transl. by E.H.W.

**N73-19069** School of Aerospace Medicine, Brooks AFB, Tex. Ophthalmology Branch

**HISTORY, RATIONALE, AND VERIFICATION OF COLOR VISION STANDARDS AND TESTING IN THE UNITED STATES AIR FORCE**

Thomas J. Tredici, James L. Mims, III, and James F. Culver. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 10 p. refs. (For availability see N73-19065 10-04)

The color vision testing and selection procedures utilized in World War II by the US Army Air Corps are reviewed. The color vision standards for flying in the US Air Force recently were changed for the first time since World War II. Men with defective scores of 50 or better on the SAM color threshold test are now accepted into flying training. A ten-year retrospective study of 4801 experienced flying personnel provides strong evidence that these standards are valid. The handling of color vision defective cases is also outlined.

Author

**N73-19070** National Defence Medical Centre, Ottawa (Ontario). Dept. of Ophthalmology

**COLOR VISION IN THE CANADIAN ARMED FORCES**

Bryan St. L. Liddy. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 6 p. (For availability see N73-19065 10-04)

Color vision in the Canadian Armed Forces is reviewed, including their standard tests: Ishihara standards book test, Green Edwards lantern test, and A.O. isochromatic book test. Different requirements of color vision for the various service branches are described. Minimum color vision standards for the initial assignment to trades within the armed forces are listed in tabular form.

1 AM

**N73-19071** Centre de Medecine Aeronautique, Brussels (Belgium)

**STANDARDIZATION OF TEST AND CATEGORIZATION OF COLOR VISION ANOMALIES IN MILITARY CIRCLES, AND METHODS USED BY EMPLOYEES TO TRACK DOWN THEIR PROBLEMS [ESSAI DE STANDARDISATION DE LA CATEGORISATION DES ANOMALIES DE LA VISION DES COULEURS EN MILIEU MILITAIRE, AINSI QUE DES METHODES EMPLOYEES EN VUE DE LEUR DEPISTAGE]**

J. M. VanDeCastele. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 4 p. In FRENCH. (For availability see N73-19065 10-04)

Sound scientific procedures developed to categorize color vision abnormalities in a uniform manner are discussed. The classification of individuals was made as a function of the number of error responses to tests, the nature of the abnormality and the gravity of the condition.

Transl. by E.H.W.

**N73-19072** Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

**COLOR VISION REQUIREMENTS IN DIFFERENT OPERATIONAL ROLES**

D. H. Brennan. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 9 p. refs. (For availability see N73-19065 10-04)

Color vision in the various operational roles of the Royal Air Force and Army Air Corps was studied. It is considered that good color acuity, although playing a valuable part in the total process of visual perception, is not of paramount importance in

would be possible by altering the present chromaticities of red and green signal colors to admit for all aircrew duties, except those of close air support, the more severe grades of red green defective. It is thought, however, that the small gain in recruiting would not warrant the resulting expense and disruption of present services. The pseudo-isochromatic plates provide a simple and rapid method of detecting even minor anomalies of color vision. With present standards, the lantern is the best trade test for grading color defectives as fit or unfit for aircrew duties. Should standards be lowered it would be necessary to supplement the lantern with a quantitative test which should be related, if possible, to the role envisaged for the candidate. Author

**N73-19073** Army Aeromedical Research Lab., Fort Rucker, Ala. **AIRCREW COLOR VISION REQUIREMENTS**  
Robert W. Bailey. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 4 p. (For availability see N73-19065 10-04)

A study revealed no statistical difference in accident rates between a selected population of color defectives and a matched sample of normals. The only significant difference demonstrated was between serious accidents in which the color normals were involved in a greater number of accidents (statistically significant) than color defectives. Operational testing of difficult cases are also presented. Author

**N73-19074** Walter Reed Army Medical Center, Washington, D.C. **PREDICTING VISUAL PERFORMANCE IN AVIATORS (COLOR VISION)**

Budd Appleton. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 5 p. (For availability see N73-19065 10-04)

The whole concept of physical standards for personnel selection is reviewed, emphasizing visual performance for aviators. Color vision tests as predictive indicators of flying task performance are evaluated. Experience with a battery of tests as part of an aeromedical in-flight evaluation is recorded in tabular form for 12 aviators. J.A.M.

**N73-19075** Headquarters Army Aviation, Middle Wallop (England). Dept. of Aviation Medicine. **HELICOPTER FLYING AND COLOUR VISION**  
I. C. Perry. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 4 p. refs. (For availability see N73-19065 10-04)

When problems are encountered in low level helicopter flying, under poor light and in featureless terrain, difficulties arise where colors have to be used for information presentation and to isolate certain items of information. Instrument lighting, map colors and marking can all become problem areas when the operators color vision is abnormal. Differences are found in methods of color vision testing. The use of colored smokes against varying backgrounds can lead to mistakes, as can wiring diagrams and wire markings. Author

**N73-19076** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. **COLOR VISION REQUIREMENTS FOR AIR CREW PERSONNEL OF THE FUTURE**  
Walter F. Grether. In AGARD Colour Vision Requirements in Different Operational Roles. Nov. 1972. 7 p. refs. (For availability see N73-19065 10-04) (AMRL-TR-71-118)

Color has unique value as a means of coding visually presented information. This was shown by experimental evaluations of alternate coding methods, such as pattern, size, intensity and flash rate. A reduction in color vision selection standards for flight personnel, such as the pilot, would require the replacement of color with other and potentially less efficient visual coding methods. Such a change would restrict the visual display choices available to the designers of future information presentation equipment, both airborne and ground. An examination of past trends and current equipment development indicates that

the use of color for coding information used by flight personnel will probably be increasing rather than decreasing in the future. Author

**N73-21092#** Advisory Group for Aerospace Research and Development, Paris (France). **PREDICTABILITY OF MOTION SICKNESS IN THE SELECTION OF PILOTS**

M. P. Lansberg, ed. Feb. 1973. 69 p. refs. Partly in ENGLISH, partly in FRENCH. Proc. of Aerospace Med. Panel Specialist Meeting, Glasgow, 7 Sep. 1972. (AGARD-CP-109) Avail. NTIS HC \$5.50

Susceptibility and factors contributing to motion sickness are examined. The Air Force and Navy tests for motion sickness predictions are described. Drugs that counteract the air sickness are considered. Blind fish responses to gravitational changes during parabolic flight are also studied. For individual titles, see N73-21093 through N73-21101.

**N73-21095** Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario). **MEASUREMENT OF SUSCEPTIBILITY TO MOTION SICKNESS**

K. E. Money. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1973. 4 p. refs. (For availability see N73-21092 12-04)

Three different bases were suggested for predicting susceptibility to motion sickness in a specific vehicle. These are (1) history of motion sickness, (2) susceptibility to motion sickness in a laboratory device, and (3) laboratory vestibular and other tests. These techniques were reviewed, and their usefulness was assessed. It was concluded that the laboratory vestibular and other tests are without practical value. Susceptibility to motion sickness laboratory devices and history of motion sickness were used and have significant predictive value. Consideration of these techniques for selection of aircrew candidates includes a comparison of the economic and other advantages of elimination of most air sickness problems and the disadvantages of the testing expense and the loss of some candidates who would not actually have had difficulty with motion sickness. Author

**N73-21094** Centre d'Etudes et de Recherches de Médecine Aéronautique, Paris (France).

**POSSIBILITY OF PREDICTING PREDISPOSITION OF MOTION SICKNESS IN THE SELECTION OF PILOTS (POSSIBILITE DE PREVOIR LA PREDISPOSITION AU MAL DES TRANSPORTS LORS DE LA SELECTION DES PIOTES)**  
G. Legoux, J. C. Hadni, M. Gouars, R. Gelly, and A. P. Gibart. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1973. 9 p. In FRENCH. (For availability see N73-21092 12-04)

The medico-aeronautical basis of selecting pilot personnel in relation to motion sickness is outlined. Human factors, aeronautical factors, and natural evolution of motion sickness in the pilots are described in detail. Selection techniques cover neuromuscular, neurovegetative, and psychological examinations, and flight experience. Transl. by E.H.W.

**N73-21096** Leicester Univ. (England). Dept. of Psychology. **FACTORS CONTRIBUTING TO MOTION SICKNESS SUSCEPTIBILITY, ADAPTABILITY AND RECEPTIVITY**  
James Reason (Naval Aerospace Med. Res. Lab., Pensacola, Fla.) and Ashton Graybiel. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1973. 15 p. refs. (For availability see N73-21092 12-04)

Evidence is presented to show that two perceptual factors, receptivity and adaptability, contribute to variation in motion sickness susceptibility. An attempt is made to integrate these two sources of variation into a neural mismatch theory of motion sickness. Two original studies are briefly reported. In the first, positive and significant relationships were obtained between measures of adaptability and (1) a personal history measure of susceptibility, (2) loss of well-being during exposure to cross-coupled angular accelerations, and (3) a questionnaire measure of introversion. It was also found that adaptability and receptivity

are unrelated factors, and that, of the two, adaptability exerted the most potent influence upon susceptibility. Yet, among slow adapters only, there was some evidence to show that receptivity contributed to individual differences in proneness. The second study was concerned with the long-term retention of protective adaptation. Author

**N73-21096** Naval Aerospace Medical Research Lab., Pensacola, Fla.

**ASSESSMENT OF REACTIONS TO VESTIBULAR DISORIENTATION STRESS FOR PURPOSES OF AIRCREW SELECTION**

Fred E. Guedry and Rosalie K. Ambler. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1973. 8 p. refs. (For availability see N73-21092 12-04)

Several tests are described which are useful for predicting individuals who will separate from air training because of airsickness and/or disabling anxiety toward flight. These tests are based on measures of immediate reactions to disorientation stress. It is desirable to have a further diagnostic assessment of individuals to determine the underlying causes of differences in reactivity to disorientation stress and also to estimate the individual's likelihood of success in the light of other predictor variables. The disorientation stress tests significantly augment other aviator predictor variables, and they appear to be significantly correlated to several personality measures. A particular visual display and task were used that produced significantly more sickness than did other tasks during comparable vestibular stimulation. The test procedure was changed and a procedure was developed which appears practical for assessing individual differences in accommodation to intersensory conflict between the visual and vestibular systems. The changed procedure did not produce sickness, and the results indicate that a 57 percent mean improvement in visual performance during vestibular stimulation can occur after only a 10-minute habituation schedule. At least part of the improvement in visual performance appears attributable to increased visual control over vestibular reflex control of the eyes. Author

**N73-21097** Naval Aerospace Medical Research Lab., Pensacola, Fla.

**MOTION SICKNESS QUESTIONNAIRE AND FIELD INDEPENDENCE SCORES AS PREDICTORS OF SUCCESS IN NAVAL AVIATION TRAINING**

Robert S. Kennedy. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1973. 5 p. refs. (For availability see N73-21092 12-04)

The usefulness of two paper and pencil tests in predicting the likelihood of success in Naval aviation training is reported. Several years experience with a motion sickness questionnaire is reviewed. Literature and theories related to motion sickness are surveyed, and a group-administered personality test is reported. The motion sickness questionnaire (MSQ) was empirically validated against an experimental procedure for producing motion sickness symptomatology (N = 100), and in a larger group (N = 802) scores on the questionnaire were statistically related to the likelihood of aviation training success. Refinements in the scoring improved the predictive ability of the MSQ (N = 660) and cross-validated successfully (N = 550). Author

**N73-21098** School of Aerospace Medicine, Brooks AFB, Tex. Biodynamics Branch

**THE USAFSAM SELECTION, TEST, AND REHABILITATION PROGRAM OF MOTION SICK PILOTS**

Patrick J. Dowd. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1972. 10 p. refs. (For availability see N73-21092 12-04)

The USAF School of Aerospace Medicine biaxial stimulator was used to impose standardized Coriolis stimuli for the purpose of determining a subject's tolerance of this very disturbing stimulus. This test differentiates the nonsick (NS) individuals from the sick (S) ones within each peer group (navigators, pilots, and airman trainees) and is a valuable indicator of the level of resistance an individual has to Coriolis accelerations and is a selection tool for an individual's resistance to motion sickness. The results of this type of test (pilots NS 299, S 51, navigators NS 80,

S 34, airman trainees NS 91, S 19, pentathlon athletes NS 14, S 0) can greatly assist in the overall selection of personnel in preflight, postflight, and in-training programs. Author

**N73-21099** Centre de Medecine Aeronauique, Brussels (Belgium)

**THE SELECTION AND SURVEILLANCE OF STUDENT PILOTS WITH MOTION SICKNESS IN THE BELGIAN ARMED FORCES (LA SELECTION ET LA SURVEILLANCE DU POINT DE VUE MAL DE L'AIR DES ELEVES-PILOTES DES FORCES ARMEES BELGES)**

S. Tribel. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1972. 3 p. In FRENCH (For availability see N73-21092 12-04)

A method of selecting and observing student pilots of the Belgian Air Force is given. Based on this method, 1500 students were admitted to pilot school in 1960 and 1972. Of this number only 7 were eliminated for established cases of motion sickness. Transl. by E. H. W.

**N73-21100** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**TEST RESULTS ABOUT THE EFFECTIVENESS OF METIXENUM APPLIED AGAINST MOTION SICKNESS**

Christian Henning. In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1973. 4 p. refs. (For availability see N73-21092 12-04)

Thirty healthy subjects were tested in a spatial disorientation demonstrator (SDD) in order to compare the effectiveness of Metixenum and Meclocin under double blind comparison test conditions against motion sickness with statistical evaluation. Metixenum reduced all subjective symptoms significantly. Its efficacy was higher than that of Meclocin. Simultaneously recorded objective symptoms (post-rotatory vertigo sensation, heart rate, results of a walking balance test) were not significantly influenced. Author.

**N73-21101** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**RESPONSES OF BLIND FISH TO GRAVITATIONAL CHANGES AS ACHIEVED IN PARABOLIC FLIGHT**

R. J. VonBaumgarten (Mich. Univ., Ann Arbor), G. L. Shillinger, Jr. and G. Bairdright (Mich. Univ., Ann Arbor). In AGARD Predictability of Motion Sickness in the Selection of Pilots. Feb. 1972. 4 p. refs. (For availability see N73-21092 12-04)

Blind fish, during parabolic flight, display a measurable and consistent behavior. The most spectacular new behavioral response is the forward looping of blind fish in or near weightlessness. This response shows no measurable adaptation during the entire period of weightlessness of about 30 sec. During the entrance and exit of weightless parabolas (pushover and pullout) respectively, the fish assumes a forward tilted diving position. Parabolic flight with negative g in the range between 0 g and -1 g causes similar diving responses of the fish with the only difference being that the dive is directed toward the top of the fish tank. When the response to a g value less than -1 g is compared to the response to increased g load on the ground (escape or darting response) an essential difference is seen: higher horizontal acceleration or jerk on the ground causes fish to swim, or even dart, against the direction of inertial force, fish during weightless parabolas move into the direction of the inertial or gravitational force. Since the vestibular system of fish is homologous to that of man, the observed behavior of fish in weightless flight could help to better understand human performance and sensations in comparable situations. Author

**N73-21102** Advisory Group for Aerospace Research and Development, Paris (France)

**THE USE OF MEDICATION AND DRUGS IN FLYING PERSONNEL**

Heinz S. Fuchs, ed. Feb. 1973. 154 p. refs. Partly in ENGLISH, partly in FRENCH. Proc. of Aerospace Med. Panel Specialist Meeting, Glasgow, 5-6 Sep. 1972. (AGARD CP-108; Avail. NTIS HC \$9.75)

Drug effects on flight fitness and the evaluation, detection, and identification of drugs and alcohol in flying personnel are discussed. For individual titles, see N73-21103 through N73-21126.

**N73-21103** Advisory Group for Aerospace Research and Development, Paris (France)  
**TECHNICAL EVALUATION REPORT, CONCLUSION, RECOMMENDATIONS**

Heinz S. Fuchs. *In its The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 13 p. refs. (For availability see N73-21102 12-04)

Inasmuch as flying effectiveness depends on an optimum degree of psychosomatic fitness, it is axiomatic that the need in a flyer for drugs should raise serious doubts as to his fitness to fly. Increasing age of the flying population is the major contributing factor since there is an increased incidence of disease commonly associated with aging. Improved diagnostic techniques and augmented information about normals and early disease have also had a significant influence upon both the types of problems evaluated and their disposition. The flight surgeon must keep well informed on all drugs, particularly newly accepted ones, so that no medication will be prescribed which might compromise flight safety. Individual susceptibility and hypersensitivity to drugs in general must always be considered. In certain situations drug therapy is warranted to prevent complications and to effect an improvement in long term prognosis. Another problem is acute illness, wherein drug therapy is warranted either to treat primarily the etiology of the disease or more frequently merely to control the symptoms in a self-limited condition. Author

**N73-21104** Federal Aviation Administration, Washington, D.C.  
Office of Aviation Medicine

**THE CURRENT STATUS OF DRUG USE IN CIVIL AVIATION PERSONNEL**

Peter V. Siegel and Stanley R. Mohler. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 4 p. (For availability see N73-21102 12-04)

Screening data concerning U.S. civil airmen while being medically certified during the period July 1971 - April 1972 are reported. In the sample studied, two percent of pilots and three percent of ground control personnel had positive urines. The positives included barbiturates, amphetamines, codeine, morphine, and methadone. Author

**N73-21105** Royal Air Force Hospital, Ely (England)

**MEDICATION AND DRUGS IN AIRCREW**

H. B. Kelly. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 4 p. refs. (For availability see N73-21102 12-04)

The attitudes adopted by the Royal Air Force and British civil aviation toward medication and drugs taken by their aircrew are discussed and recommendations made. Author

**N73-21106** Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

**USE OF HYPNOTICS BY AIRCREW. 1. OPERATIONAL CONSIDERATIONS AND EXPERIMENTAL STUDIES**

A. N. Nicholson and Catherine M. Wright. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 5 p. refs. (For availability see N73-21102 12-04)

The residual effects of hypnotic drugs for normalizing aircrew sleeping patterns on human nervous function and performance are studied. Delayed matching-to-sample tests on monkeys show that barbiturates do not affect matching-to-stimuli time, but some benzodiazepines increase response times up to 6 hrs after administration. G.G.

**N73-21107** Air Corporations Joint Medical Service (BEA/ROAC), London (England)

**ASPECTS OF SLEEP REGULATION IN AIRLINE PILOTS**

F. S. Preston. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 8 p. refs. (For availability see N73-21102 12-04)

Probably the greatest problem facing long haul civil airlines is the need to ensure that pilots are given adequate time while

on a tour of duty to ensure sufficient sleep and so enable them to cope successfully with the ensuing period of work. The problem on long haul routes is greatly compounded by the effect of time zone changes, night flights and changes of a climatic nature which all affect the individual's ability to achieve sleep on arrival. There is definite evidence of cumulative sleep loss on longer trans-meridian routes. As a result, the individual pilot may be tempted to use hypnotics which he can purchase freely over the counter in some parts of the world without medical supervision. In addition, he may use alcohol for its hypnotic action or combined with other hypnotics which may affect not only his fitness to fly on the next day, but have addictive and cumulative effects. The problems are discussed for a long haul airline and some suggestions are made for controlling the situation from both the medical and executive standpoints. Author

**N73-21108** Royal Air Force Central Medical Establishment, London (England)

**AVIATED POLICY ON SLEEP IN AIRCREW**

P. J. O'Connor. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 2 p. (For availability see N73-21102 12-04)

The role of the aviation medical practitioners in relation to aircrew sleep is to instruct the crews in how to anticipate sleep requirements and the best physiological ways of encouraging adequate sleep. Hypnotics should not be used by crews to get sleep as they cause decrement in performance during the subsequent day. Author

**N73-21109** Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

**USE OF HYPNOTICS BY AIRCREW. ADAPTIVE TRACKING AS A TECHNIQUE FOR THE EVALUATION OF PERFORMANCE DECREMENTS RELATED TO THE FLYING TASK**

R. C. Borland and A. N. Nicholson. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 5 p. refs. (For availability see N73-21102 12-04)

The mean performance of 6 subjects tested following the oral administration of secobarbitone at a dose of 3.3 mg/kg of body weight in an adaptive tracking task provides a reasonable approach to evaluating drug after-effects of possible significance to the flying task. Nevertheless, training of personnel and the experimental procedures involved demand considerable effort on the part of subjects and experimenters. Author

**N73-21110** Centre d'Essais en Vol, Bretigny-sur-Orge (France).  
**MODIFICATIONS OF PERFORMANCE UNDER CERTAIN MEDICATIONS: PROPOSED MEASURING METHOD [MODIFICATIONS DE LA PERFORMANCE SOUS L'INFLUENCE DE CERTAINS MEDICAMENTS: A PROPOS D'UNE METHODE DE MESURE]**

R. Auffret, R. Angiboust, and J. Demange. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 5 p. refs. *In FRENCH* (For availability see N73-21102 12-04)

The influence of tranquilizers, hypnotic drugs, and barbiturates on the performance of navigation personnel is investigated. Reaction time, personnel efficiency during complex tasks, and psychological factors were measured. It was determined that some drugs - Fluphenazine, Trifluoperazine, and Prenylamine - do not affect performance, while hypnotic drugs and tranquilizers show some definite performance decrement. Transl. by E.H.W.

**N73-21111** Army Aeromedical Research Lab., Fort Rucker, Ala.  
**THE EFFECTS OF INH CHEMOPROPHYLAXIS ON AVIATOR PERFORMANCE**

Mark A. Hofmann. *In AGARD The Use of Medication and Drugs in Flying Personnel*. Feb. 1973. 8 p. refs. (For availability see N73-21102 12-04)

A group of tuberculin positive, healthy aviators taking INH prophylactically at dosages of 300 mg. daily for one year were maintained on flying status while simultaneously participating in a study to determine the effects of this drug therapy. This investigation measured performance on a number of laboratory tasks to include pursuit tracking, mental multiplication, digit span, reaction time and combinations of the above. No decrements in

performance were observed in this performance as a function of drug treatment. Additionally, these aviators' physical state was assessed by measuring a host of physiological parameters during their year of therapy. There was no evidence of severe drug reactions. It was recommended that aviators be allowed to continue flying duties while taking INH at these dosage levels, but in the interest of safety, a regular program of careful clinical observation and periodic measurements of transaminase levels be conducted. Author

N73-21112 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany). Inst fuer Flugmedizin

**THE PREDICTION OF FLIGHT SAFETY HAZARDS FROM DRUG INDUCED PERFORMANCE DECREMENTS WITH ALCOHOL AS REFERENCE SUBSTANCE**

Karl E Klein. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb 1973. 12 p. refs (For availability see N73-21102 12-04)

A modification of CNS activity resulting in a decrement of performance is the most unwanted side effect of drugs in active flying personnel. A procedure is described where hazard prediction is accomplished with ethanol as reference substance through the following steps: (1) Evaluation of dose-effect-relationship for ethanol with the performance test to be applied in toxicological drug studies, and (2) Examination of drug with the alcohol calibrated test method, estimation of the alcohol intoxication level equipotential in its performance decrement to the drug dose studied, definition of the operational significance of the drug induced performance changes by reference to the intoxication-hazard-relationship established for alcohol, prediction of the critical drug dose through extrapolation. Results with sedative, neuroleptic, tranquilizing and stimulating drugs are demonstrated and the advantage and limitations of the reference procedure discussed. Author

N73-21113 Ohio State Univ., Columbus. Aviation Medicine Research Lab

**ETHYL ALCOHOL AND PILOT PERFORMANCE: MILITARY IMPLICATIONS OF IN-FLIGHT STUDIES**

C. E. Billings, R. L. Wick, Jr., R. J. Gerke, and R. C. Chase. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb 1973. 11 p. refs (For availability see N73-21102 12-04)

Sixteen instrument-rated civil pilots flew 501 instrument landing system approaches in a light airplane at night under simulated instrument flight conditions while sober and while under the influence of .04, .08 and 12 G% blood ethyl alcohol concentrations. Data included continuous measurement of deviations from localizer and glide path centerline, note was made of all procedural errors. While the highly experienced pilots maintained better tracking performance than the less experienced subjects, particularly at high blood alcohol levels, both groups demonstrated progressive increases in the number and seriousness of procedural errors with each increase in alcohol level. These results indicate that alcohol-induced performance degradation may occur first in secondary tasks rather than in the primary flying task. They also indicate that there is potentially dangerous deterioration in the performance of even highly skilled aviators at blood alcohol levels as low as .04%. Author

N73-21114 Caen Univ. (France). Faculte de Medecine et de Pharmacologie

**THE OPTIMIZATION OF FORM [L'OPTIMISATION DE LA FORME]**

Robert N. Lemaire. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb 1973. 3 p. In FRENCH (For availability see N73-21102 12-04)

Sports medicine, in relation to the effects of drugs on physical and psychological performance, is discussed. Three points were established for good physical form during competitive activities. They are: (1) maintenance of electrolytic equilibrium, (2) supplementation of normal vitamin levels, and (3) regulation of acid overloads. Transl. by E.H.W.

N73-21115 Mainz Univ. (West Germany). Inst. of Forensic Medicine.

**DRUG USE AND PERFORMANCE**

J. G. Gostomzyk, P. Parade, and H. Gewecke. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb 1973. 5 p. refs (For availability see N73-21102 12-04)

Psychological and physiological effects of acute cannabis intoxication are considered. It is shown that hashish smoking does not affect oxygen consumption in man. However, performance requirements in driving a car under the influence of the drug appear to be felt as stress which demands a response from a psychologically stimulated high energy level. Reduced performance capability manifests itself if actual stress situations are superimposed upon the normal task. It is concluded that hashish impairs the ability to drive safely. G.G.

N73-21116 BioTechnology, Inc., Falls Church, Va.

**USE OF SPECTRAL ANALYSIS PROCEDURES FOR THE EVALUATION OF DRUG EFFECTS**

James F. Parker, Jr. and Thomas W. Frazier (Walter Reed Army Inst. of Res., Washington, D. C.). In AGARD The Use of Medication and Drugs in Flying Personnel. Feb 1973. 9 p. refs (For availability see N73-21102 12-04)

The use of spectral analysis procedures in the study of drug effects is described in an attempt to develop a more sensitive and meaningful index of performance change. Spectral analysis procedures use time series data in which basic biorhythmicities in performance are identified and studied as the subject is exposed to a stress condition (drug administration). Oscillatory performance profiles are transformed from the time domain to power spectra. These spectra then are examined by means of statistical coherence estimates. Changes in the coherence of these biorhythms provide a measure of the extent to which the organization of a complex performance has been disrupted by the stress condition. Subjects were administered a tranquilizing drug (chloridiazepoxide) under double-blind conditions. A significant loss of coherence was found for the performance of a vigilance task. No change was found in the accompanying physiological measures: heart rate and rectal temperature. These results clearly show a drug induced desynchronization of performance in a human data processing activity. It is concluded that spectral analysis techniques may be of value as one tool in the complete evaluation of drug effects. Author

N73-21117 School of Aerospace Medicine, Brooks AFB, Tex.

**DRUG ABUSE DETECTION EFFORTS**

George D. Lathrop, Harold L. Kaplan, and Jack E. Wallace. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb 1973. 4 p. refs (For availability see N73-21102 12-04)

Operational efforts to detect drug abuse by mass-screening urinalysis are summarized. Particular emphasis is given to the current analytical methods used to detect opiates, barbiturates, and amphetamines. Advantages and disadvantages of available methodology are presented to provide rationale guidelines for establishing an accurate and forensically reliable toxicology laboratory. Methods of thin layer chromatography and gas-liquid chromatography offer unparalleled detection accuracy for drugs of abuse, as well as a capability to analyze therapeutic levels of certain psychotropic drugs (tranquilizers, antihistamines) of specific concern in flying populations. Tandem research efforts to improve current methodology for the diethylamide of lysergic acid (LSD), tetrahydrocannabinols (THC), and methadone, and to develop new tests based on individual enzymatic changes, are briefly presented. Author

N73-21118 Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

**USE OF HYPNOTICS BY AIRCREW: CONSIDERATIONS OF METABOLISM AND EXCRETION**

J. M. Clifford and J. H. Cookson. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb 1973. 6 p. refs (For availability see N73-21102 12-04)

The metabolism of secobarbital, heptobarbital and the

nonbarbiturate hypnotic methaqualone have been studied in man using the technique of gas liquid chromatography. A polarographic technique for plasma levels of nitrazepam has also been investigated. Author

**N73-21119** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

**THE IMPACT OF DIURNAL RHYTHM ON DRUG DOSING AND DRUG EVALUATION**

H. W. Kirchhoff. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 4 p. (For availability see N73-21102 12-04)

The well known fact that the functional behavior of the human organism is subjected to a rhythmically occurring daily process is still being disregarded in clinical practice and pharmacology. Drug dosing, instead of sticking to the stereotyped pattern of 3 x 1 tablet/day, requires full consideration of the diurnal variations which occur in the human body involving mainly cardiovascular parameters. Drug evaluation, on the other hand, should also include careful studies in diurnal rhythm in order to obtain precise data on the duration and onset of drug action as well as on specific influence emerging in the course of the day, all the more since any approach of this kind will contribute to the elimination of untoward side effects and other hazardous influences which may be attributed to a drug. Author

**N73-21120** Hopital d'Instruction des Armees, Versailles (France)  
**ANTI-DIABETIC MEDICATIONS AND NAVIGATION PERSONNEL (MEDICAMENTS ANTIDIABETIQUES ET PERSONNEL NAVIGANT)**

Roger Pannier and Gerard Leguay. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 6 p. In FRENCH (For availability see N73-21102 12-04)

The use of antidiabetic drugs and the fitness of such people as navigation personnel are examined. It was determined that the insulin-dependent sugar diabetic is unfit for such jobs because he is subject to keto-acidotic accidents, hypoglycemia, and regimented diets unsuited for his job. In non-insulin dependent diabetics who are maintained by oral drugs, it was determined that those who use sulphonylureas are also unsuited for flying duties since this drug sometimes causes hypoglycemia. Diabetics taking biguanide, it was determined, may under exceptional circumstances become or continue to be flying personnel. These drugs do not produce hypoglycemia as do the other medicaments studied. Transl. by E.H.W.

**N73-21121** Royal Air Force Hospital, Ely (England)  
**OCULAR SIDE EFFECTS OF DRUGS IN AVIATION MEDICINE**

G. W. T. Smith. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 2 p. (For availability see N73-21102 12-04)

Many drugs which may be prescribed for aircrew or used by aircrew in self medication have known reported ocular side effects which can affect visual performance. Reviewed are some of the main groups of these drugs, drawing attention to these side effects. Author

**N73-21122** Advisory Group for Aerospace Research and Development, Paris (France)

**OPHTHALMOLOGIC SURVEILLANCE OF ABSORBED ANTIMALARIAL DRUGS IN SYSTEMS OF NAVIGATION PERSONNEL (SURVEILLANCE OPHTHALMOLOGIQUE DU PERSONNEL NAVIGANT ABSORBANT DES ANTIPALUDEENS DE SYNTHÈSE)**

J. P. Chevaleraud (CPEMPN, Paris). In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 5 p. In FRENCH (For availability see N73-21102 12-04)

Observations of synthetic antimalarials, through ophthalmological methods, in the systems of navigation personnel were made. Risks to test subjects and toxic side effects are discussed. Transl. by E.H.W.

**N73-21123** Flugzeugfuehrerschule, Klier, Heidorn (West Germany)

**TRANQUILIZERS AND AVIATION**

Heinrich Schulte-Wintrop. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 4 p. refs. (For availability see N73-21102 12-04)

The use of tranquilizers during periods of flying duty is still infrequent and no direct effects on flight safety have so far been positively observed; there is, however, a danger of such effects in case of excess dosage and use of ataractics such as diazepam. A potentiating effect by alcohol has been described in some cases, but the influence of alcohol alone appears to be the crucial factor in these cases. It is shown that ataractics like chlorthalidone fail to alleviate stress reactions in student pilots, but that the application of certain tranquilizers in treating different types of kinetosis seems promising. The prescription of tranquilizers should be avoided until the effects these medicaments have in combination with the varied strains encountered in aviation have been fully surveyed. Author

**N73-21124** Fighter Bomber Wing (31st), Kerpen/Erft (West Germany)

**USE OF MEDICATION AND DRUGS, ESPECIALLY ALCOHOL BY FLYING PERSONNEL**

Hugo Hambach. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 5 p. refs. (For availability see N73-21102 12-04)

Alcohol is the most common and most dangerous drug used by pilots. Three simple methods are described by which the blood alcohol can be determined: (1) By means of two tables pilots are able to determine the approximate level of blood alcohol concentration after the consumption of a known amount of alcoholic beverage over a given period of time; (2) the detection of the gross post-rotational nystagmus which is found whenever the central nervous system has been affected by alcohol; and (3) a semi-quantitative method of breath analysis for alcohol detection in the blood. These three methods make it possible to single out pilots who have alcohol in their blood and to prevent them from flying. Author

**N73-21125** Centre d'Essais en Vol, Brétigny-sur-Orge (France)  
**EFFECT OF ALTITUDE ON CEREBRAL BLOOD FLOW PATTERNS IN THE SMOKER AND NONSMOKER (ACTION DE L'ALTITUDE CHEZ LE FUMEUR ET LE NON FUMEUR SUR LES VARIATIONS DU DÉBIT SANGUIN CÉRÉBRAL)**

J. Demange and R. Auffret. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 5 p. refs. In FRENCH (For availability see N73-21102 12-04)

Variations in the cerebral blood circulation of smokers and nonsmokers as a function of altitude are measured rheographically. Also measured were the effects of vasometric drugs, altitude tolerance, chronic hypoxia, and performance as influenced by blood flow. Transl. by E.H.W.

**N73-21126** Institute of Pharmacology, Oslo (Norway)  
**COMPARISON OF MENTAL AND PSYCHOMOTOR EFFECTS OF DIAZEPAM AND ETHANOL**

J. F. W. Hafner et al. In AGARD The Use of Medication and Drugs in Flying Personnel. Feb. 1973. 10 p. refs. (For availability see N73-21102 12-04)

Whether and to what extent a single, large therapeutic dose of diazepam affects mental and psychomotor functions in man was determined. The effects of diazepam in dosages of 10 and 20 mg/70 kg body weight have been compared with those of alcohol in amounts which were designed to produce blood levels of approximately 0.1%. Serum concentrations of diazepam were estimated in order to see whether it was possible to establish a correlation between dosages, serum concentrations and effects. It was shown that diazepam has a negative influence on the results of a series of tests with relevance to performance. In none of the tests was there any improvement in mean score after diazepam compared with placebo. However, a comparison of the test results reveals some differences between the effects of alcohol and diazepam. Author

**N73-23057#** Advisory Group for Aerospace Research and Development, Paris (France)

**CURRENT STATUS IN AEROSPACE MEDICINE**

Walton L Jones, ed (NASA, Washington, D C) Feb 1973  
77 p refs Presented at Aerospace Med Panel Specialist Meeting,  
Glasgow, Scotland, 7-8 Sep 1972  
(AGARD-CP-110) Avail NTIS HC \$8.00

Proceedings from an aerospace medicine conference are presented, emphasizing human tolerances to various stress factors incurred during flight. The diseases, syringomyelia and hepatitis, are considered in terms of their effect on the flying fitness of personnel. Compound breeding of Rhesus monkeys is included. For individual titles, see N73-23058 through N73-23068

**N73-23058\*** National Aeronautics and Space Administration, Washington, DC

**RECENT NASA AEROSPACE MEDICINE TECHNOLOGY DEVELOPMENTS**

Walton L Jones. In AGARD Current Status in Aerospace Med  
Feb 1973 8 p refs (For availability see N73-23057 14-04)  
CSCL 08E

Areas of life science are being studied to obtain baseline data, strategies, and technology to permit life research in the space environment. The reactions of the cardiovascular system to prolonged weightlessness are also being investigated. Particle deposition in the human lung, independent respiratory support system, food technology, and remotely controlled manipulators are mentioned briefly. J A M

**N73-23059** Naval Aerospace Medical Research Lab., New Orleans, La

**NON-FATAL EJECTION VERTEBRAL FRACTURE AND ITS PREVENTION**

Channing L Ewing. In AGARD Current Status in Aerospace Med Feb 1973 8 p refs (For availability see N73-23057 14-04)

Several studies of the nature and extent of the problem were made. Jones et al showed that 21% of 165 U.S. Navy aviators suffered vertebral fracture using a gun-type ejection seat over a 4 1/4 year period 1958-1963. (2) Of these, six were retired on disability and one additional died. Fryer found a 19% incidence in 220 RAF ejection using a similar seat. (3) Hirsch found a 25% incidence in 55 Swedish Air Force ejections using a different seat. (4) More recently, Shannon found that in the USAF during CY 1967 and 1968, there were 390 noncombat ejections with 118 persons suffering major nonfatal injury. (5) Forty-one of the major injuries were fractures due to ejection force, and 97% of these were vertebral fractures. In the combat ejections, 89% of major injuries due to ejection force were vertebral fractures, and 80% of all vertebral fractures suffered were due to ejection force. In all, 31% of noncombat and 25% of combat major injuries on ejection were nonfatal ejection vertebral fractures. In both cases the ejection vertebral fractures were the largest single category of major injury. Author

**N73-23060** Hellenic Air Force General Hospital, Athens (Greece)  
**MANAGEMENT OF ASYMPTOMATIC CARRIERS OF HEPATITIS-ASSOCIATED ANTIGEN (HAA) IN HELLENIC AIR FORCE PERSONNEL**

H G Vissoulis and C E Giannopoulos. In AGARD Current Status in Aerospace Med Feb 1973 4 p refs (For availability see N73-23057 14-04)

A large-scale investigation among Hellenic Air Force personnel was instituted in Jan 1971 aiming at detecting the asymptomatic HAA carriers and recommending means of prevention, medical disposition and/or elimination from flying and certain specialties. This systematic screening is justified by a high correlation of positive HAA and cases of acute viral hepatitis. A disquieting incidence of 5.2% of asymptomatic HAA carriers was demonstrated. Author

**N73-23061** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**SYRINGOMYELIA AND FLYING FITNESS**

Gunter Apel. In AGARD Current Status in Aerospace Med Feb 1973 3 p refs (For availability see N73-23057 14-04)

The extent to which the existing syringomyelia had contribution to fatal accidents and the question of specific flying conditions being conducive to an exacerbation of syringomyelia are discussed. Histological examinations of organs of pilots involved in fatal accidents have often revealed diseases, in particular those involving the heart, which may have limited flying fitness. Author

**N73-23062** Johann-Wolfgang Goethe-Universität, Frankfurt am Main (West Germany) Arbeitsgruppe fuer Biophysikalische Weltraumforschung

**THE BIOSTACK EXPERIMENT ON APOLLO 16**

H Buecker. In AGARD Current Status in Aerospace Med Feb 1973 6 p refs (For availability see N73-23057 14-04)

The objective of the BIOSTACK experiment, flown onboard Apollo 16, is to study the combined action of individual heavy high energy loss nuclei of cosmic radiation and space flight factors on biological systems in resting state. The results will give information on the mechanism of heavy particles on biological matter. The BIOSTACK experimental package contains a series of monolayers of selected biological objects (Bacillus subtilis spores, Arabidopsis thaliana seeds, Vicia faba radicle, Artemia salina eggs) with each layer sandwiched between several different physical track detectors (nuclear emulsions, cellulose nitrate, polycarbonate). Individual local evaluation methods were developed which identify each biological effective particle and correlate the individual hitting particle with the produced biological effect. A variety of biological effects due to a single penetrating particle is being analyzed: influence on cellular and tissue development, nuclear damages, and mutation induction. Author

**N73-23063\*** Flugwissenschaftliche Forschungsanstalt, Munich (West Germany); Yerkes Primate Research Center

**BREEDING MONKEYS FOR BIOMEDICAL RESEARCH**

Geoffrey H Bourne, M Nelly GolarzdeBourne, and Michale E Keeling. In AGARD Current Status in Aerospace Med Feb 1973 6 p refs (For availability see N73-23057 14-04)  
(NASA Order R-10-009-013, Grant RR-00185)  
CSCL 06C

Captive bred rhesus monkeys show much less pathology than wild born animals. The monkeys may be bred in cages or in an outdoor compound. Cages bred animals are not psychologically normal which makes them unsuited for some types of space related research. Compound breeding provides contact between mother and infant and an opportunity for the infants to play with their peers which are important requirements to help maintain their behavioral integrity. Offspring reared after a year in the compound appear behaviorally normal and show little pathology. Compound breeding is also an economical method for the rapid production of young animals. The colony can double its size about every two and a half years. Author

**N73-23064** Royal Air Force Inst of Aviation Medicine, Farnborough (England)

**HYBRID COMPUTING: A TECHNIQUE FOR THE IMMEDIATE ANALYSIS OF PHYSIOLOGICAL DATA**

G H Byford. In AGARD Current Status in Aerospace Med Feb 1973 4 p refs (For availability see N73-23057 14-04)

The solution must include a means for rejecting that part of the data considered to be of little importance, a technique for establishing the probable difference between two possibly similar recordings, or the probable similarity between two apparently different recordings, and the speedy processing of data, preferably but not necessarily carried out during the experiment. Much can be done with simple and easily understood statistics, a small hybrid computer, and the allocation of a little thought to the problem as a whole rather than to its isolated parts. These processes are illustrated by considering the real-time analysis of a multichannel electrophysiological recording, using uncomplicated mathematics and the parallel-serial hybrid computing installation. Author

**N73-23065** School of Aerospace Medicine, Brooks AFB, Tex  
Applied Physiology Branch

**AEROMEDICAL EVALUATION OF THE PHASED-DILUTION CONCEPT FOR OXYGEN BREATHING SYSTEMS**



Robert W. Krutz, Jr., William J. Sears, Kenneth G. Gould, Jr., and Richard W. Bancroft. In AGARD Current Status in Aerospace Med. Feb. 1973. 7 p. refs. (For availability see N73-23057 14-04)

This series of studies was designed to compare the relative effectiveness of phased-dilution with current demand-diluter oxygen delivery systems in artificially ventilated dogs and in seated, quietly breathing humans. The arterial oxygen tension approximately doubled in the canine model with the phased-dilution oxygen delivery when compared with comparable quantities of premixed oxygen at ground level and at simulated altitudes of 10,000 and 18,000 feet in a decompression chamber. Arterial oxygen tensions in humans breathing in a random fashion were higher with the phased-dilution oxygen delivery system than with comparable quantities of premixed oxygen. Human arterial oxygen tensions measured with the phased-dilution technique at ground level and in a chamber at subatmospheric pressures equivalent to altitudes of 10,000 and 18,000 feet were less than predicted from the canine work. It appears that this more limited effectiveness is closely related to a respiratory dead space effect and is influenced by frequency and depth of breathing with a fixed bolus. Author

N73-23066 Naval Aerospace Medical Research Lab., New Orleans, La.

#### **SPECIALIZED ANTHROPOMETRY REQUIREMENTS FOR PROTECTIVE-EQUIPMENT EVALUATION**

Daniel J. Thomas. In AGARD Current Status in Aerospace Med. Feb. 1973. 8 p. refs. (For availability see N73-23057 14-04)

Anthropometry was considered from the point of view of its application to problems of protective-equipment evaluation, human impact-acceleration experiments, and flying personnel populations. The difficulties of supplying data for all three areas of endeavor are discussed. A three-dimensional anatomically referenced basis for recording anthropometric data is offered as an adequate approach. Coordinate systems for the head and the first thoracic vertebral body are described. Author

N73-23067 Office of the Air Force Surgeon General, Washington, D.C.

#### **HUMAN EXPOSURE CRITERIA TO LASER ENERGY**

Donald I. Carter, William E. Mabson, and James F. Culver. In AGARD Current Status in Aerospace Med. Feb. 1973. 5 p. ref. (For availability see N73-23057 14-04)

The United States Air Force is adapting laser technology to many combat and combat support uses. Some of these uses include distance measuring to assist in aiming airborne guns in the AC-130 gunships, boresighting guns on fighter aircraft, and target marking for accurate aerial bombing. The number of different lasers and their uses are increasing. Since these high energy monochromatic light beams can produce biological damage, safe exposure criteria are needed to assist in developing safe exposure distances, protective devices, and medical surveillance programs. Author

N73-23068 Centro di Studi e Ricerche di Medicina Aeronautica e Spaziale, Rome (Italy)

#### **STUDY ON SOME AIR FORCE OPERATIONAL ACTIVITIES IN ITALY, WITH REFERENCE TO THERMAL CONDITIONS AND THEIR EFFECTS ON ACCELERATION TOLERANCE AND PSYCHOMOTOR PERFORMANCE**

Penin Rota. In AGARD Current Status in Aerospace Med. Feb. 1973. 10 p. refs. (For availability see N73-23057 14-04)

Climate in Italy, in summer period, presents such characteristics that, in Air Force operational activities, performance of AF personnel can be affected. Because of this, a series of researches was carried out in this field. After a brief survey on main features of Italian climate and summer climatic conditions in some AF bases, the results are reported on microclimatic data recorded in the interior of the cockpit and inside motor vehicles cabins while parking in summer daylight period. Physiological importance of these data, and the effects on working efficiency are discussed.

and evaluated by means of some heat stress indexes. Results of experimental parallel researches are also reported to assess the effects on acceleration tolerance and psychomotor performance, of situations simulating scramble take off. Author

N74-12748# Advisory Group for Aerospace Research and Development, Paris (France)

#### **SPATIAL DISORIENTATION IN FLIGHT: A HANDBOOK FOR AIRCREW**

A. J. Benson (RAF Inst. of Aviation Med.) and E. Burchard (German AF Med Corps). Sep. 1973. 43 p. refs. (AGARD-AG-170) Avail. NTIS HC \$4.25

It has been known for many years that aircrews suffer from false sensations and perceptions of aircraft motion and that these illusions may hazard the safety of the aircraft and its occupants. This handbook considers the various manifestations of spatial disorientation, their causes and consequences for the benefits of aircrews and their medical attendants. Author

N74-13784# Advisory Group for Aerospace Research and Development, Paris (France)

#### **PATHOPHYSIOLOGICAL CONDITIONS COMPATIBLE WITH FLYING**

Heinz S. Fuchs, ed. (German Fed. Armed Forces, Bonn). Oct. 1973. 152 p. refs. In ENGLISH and FRENCH. Presented at AGARD Aerospace Med. Panel Specialist Meeting, Pensacola, Fla. 16-17 May 1973.

(AGARD-CP-129) Avail. NTIS HC \$9.75

Medical selection and maintenance procedures for aircrews are reported. The effects of ageing, flight stress, clinical and psychophysiological pathological factors on pilot flight fitness are considered. For individual titles see N74-13785 through N74-13806.

N74-13785 German Federal Armed Forces, Bonn

#### **TECHNICAL EVALUATION REPORT, CONCLUSION AND RECOMMENDATIONS**

Heinz S. Fuchs. In AGARD Pathophysiological Conditions Compatible with Flying. Oct. 1973. 10 p. (For availability see N74-13784 05-04)

In the past, physical standards have been overly conservative because it was necessary to base aeromedical criteria on medical concepts derived from experience with diseased states in hospital patients. Increasing experience with aircrew populations based upon specific studies to disclose the relationships between the pathophysiology of early disease and the psychophysiological requirements of flight, allows a more subtilized interpretation of diagnostic and clinical findings and gives now a wider and safer prognostication. Therefore, it is believed that there is a justification to change these standards - based upon systematic and scientific reevaluation, taking advantage of newly developed knowledge and research techniques. Because of the unique nature of the ageing aircrew population it is frequently necessary to accomplish this research directly upon the flyers themselves rather than to extrapolate from general medical research. Author

N74-13786 Naval Aerospace Medical Research Lab., Pensacola, Fla.

#### **THE THOUSAND AVIATORS: AGING AND THE BLOOD PRESSURE**

Robert E. Mitchell. In AGARD Pathophysiological Conditions Compatible with Flying. Oct. 1973. 3 p. (For availability see N74-13784 05-04)

Blood pressure patterns are discussed for the members of a research group over a 32 year period and the implications of the patterns. In contrast to what was previously thought to be the case, namely that blood pressure levels not rise with increasing age, the latest survey indicates that there are many and important exceptions to this generality, after 45 years of age. Since this is the period when most naval aviators enter the administrative phase of their careers, the findings less significance than if it occurred at an earlier age but has greater operational significance in the case of commercial airline pilots inasmuch as these men

continue to fly at age 60. It would appear that this late onset of elevated blood pressure justifies the more liberal standards for admission to flight training. At the same time personnel in an active flight status can be allowed to continue active flying if no complications are noted and treatment is not indicated.

Author

**N74-13787** Naval Aerospace Medical Research Lab., Pensacola, Fla.

#### ELEVATED BLOOD PRESSURE IN AIRCREW

D. R. Stoop, K. C. Stanton and D. D. Brown. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 5 p. (For availability see N74-13784 05-04)

The evaluation, management, and disposition of the aircrew with elevated blood pressure are frequently difficult problems. Analysis of evaluations reveals an obvious reluctance on the part of the physician to establish a diagnosis of hypertension and a tendency to avoid drug therapy in spite of accepted evidence that early treatment reduces morbidity. The implications and potential problems in this approach have been discussed, and current practices and policies regarding the aircrew with hypertension have been presented and defended.

Author

**N74-13788** School of Aerospace Medicine, Brooks AFB, Tex. Internal Medicine Branch.

#### RETURNING AIRMEN WITH ABNORMAL EXERCISE TESTS AND NORMAL CORONARY ANGIOGRAMS TO FLYING STATUS

Victor F. Froelicher, Frank G. Yanowitz, A. J. Thompson, and Malcolm C. Lancaster. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 7 p. refs. (For availability see N74-13784 05-04)

Individuals with ST segment changes during and/or after exercise are considered to have an increased risk of developing the manifestations of CAD (Coronary Artery Disease). However, it is also known that both the double Master's test and maximal treadmill testing yield false positive and negative results relative to CAD. The results of coronary angiography are presented in 63 asymptomatic aircrewmembers with resting repolarization abnormalities and exercise testing responses suggestive of coronary artery disease. Fifty-four per cent had angiographic coronary artery disease, and many had high risk lesions. Forty-six per cent had no angiographic lesions and were recommended for return to flying duties. The findings in this study, the lack of significant complications, the concern for public safety, and the economics of maintaining a flying force justify the continued use of elective coronary angiography in selected asymptomatic aircrewmembers.

Author

**N74-13789** School of Aerospace Medicine, Brooks AFB, Tex. Applied Physiology Branch.

#### MYOCARDIAL AND CEREBRAL FUNCTION DURING EXPOSURE TO CARBON MONOXIDE

Howard H. Erickson and Milton J. Hernandez-Perez. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 6 p. refs. (For availability see N74-13784 05-04)

Aircrew members exposed to carbon monoxide may sustain an increase in coronary blood flow and a reduction in oxygen delivery to the heart and brain. These factors may result in a decrement in man's performance in strategic and tactical weapon systems in an enemy defense environment. Since many of the stresses -- such as physical exertion, altitude hypoxia, and acceleration -- are cumulative, carbon monoxide may affect the heart and cardiovascular system of man during operational flying by decreasing still further the oxygen supply and reserve in the heart and brain.

Author

**N74-13790** Hopital d'Instruction des Armees, Versailles (France).

#### CARDIAC VALVULOPATHIES AND FLIGHT TOLERANCE [CARDIOPATHIES VALVULAIRES ET TOLERANCE AU VOL]

G. Leguay. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 12 p. refs. In FRENCH (For availability see N74-13784 05-04)

Due to exceptional circumstances 8 pilots suffering from

aortic insufficiency, aortic stenosis, and mitralis stenosis have been on flying status, aeromedically monitored up to 15 and 20 years. The cardiac valvulopathies raise a twofold problem: they may potentially endanger flight safety by leading to a sudden cardiac syncope and they can be aggravated by flying, particularly by acceleration forces. Flight safety, however, has never been threatened by these aircrew in the light of experience over several years. The tolerance of flying pilots suffering from moderate aortic insufficiency seems satisfactory, in particular in fighter pilots exposed to high g-loads.

Author

**N74-13791** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).

#### VALUE OF CARDIAC MECHANOGRAMS IN EVALUATING FLYING PERSONNEL [INTERET DES MECANOGRAMMES CARDIAQUES DANS L'EXPERTISE DU PERSONNEL NAVIGANT]

R. Carre, C. Nogues, and B. Raviart. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 14 p. refs. In FRENCH (For availability see N74-13784 05-04)

Cardiac mechanograms provide useful information in the medical evaluation of aircrew and are obtained fast and easily by a noninvasive technique. The cardiogram itself provides an estimate of the elasticity of the arterial wall, and in that way gives criteria for atherosclerosis. The combined use of chronocardiographic methods (ECG, cardiogram) provides an opportunity of validating the contractibility of the cardiac muscle. These methods are important in the cardiologic survey of aircrew, both to detect atherosclerosis and monitor arterial hypertension.

Author

**N74-13792** Hopital d'Instruction des Armees, Versailles (France). Service de Medecine Aeronautique.

#### ASTHMA IN MILITARY FLYING PERSONNEL [L'ASTHME DANS LE PERSONNEL NAVIGANT MILITAIRE]

R. Pannier. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 8 p. refs. In FRENCH (For availability see N74-13784 05-04)

Detection of bronchial asthma is based mainly on actually observed acute episodes. That is the reason why applicants for flight training will be accepted unless they are subjected to an acetylcholin test. It is well known that patients with bronchial asthma benefit from flying. However, because of its serious consequences if it occurs in flight, bronchial asthma is considered to jeopardize flight safety. It is important to realize that treatments have to be adapted to the aircrew tasks since some medications may be contraindicated for flying activities in view of their secondary effects. Therefore, applicants for flying duties suffering from bronchial asthma must be rejected; aircrew who develop bronchial asthma during an established career might be considered for a waiver on an individual basis, but as a rule they will not be authorized for primary control of aircraft.

Author

**N74-13793** Hopital d'Instruction des Armees, Versailles (France).

#### IDIOPATHIC SPONTANEOUS PNEUMOTHORAX IN FLYING PERSONNEL [LE PNEUMOTHORAX SPONTANE IDIOPATHIQUE DANS LE PERSONNEL NAVIGANT]

Roger Pannier. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 6 p. In FRENCH (For availability see N74-13784 05-04)

Rupture of subpleural blebs is considered the most frequent cause of idiopathic spontaneous pneumothorax. Idiopathic spontaneous pneumothorax can occur in flight in the course of rapid decompression, by ascent to altitude both in flight and in an altitude chamber when trapped air within these blebs expands and ruptures the thin pleural layer, by an hydrostatic hemodynamic effect, or incidentally without any concomitant exertion or any physical stress. Applicants for flight training reporting one episode of idiopathic spontaneous pneumothorax must be rejected; aircrew on active duty and with an established flying career must be grounded unless they have undergone successful pulmonary surgery. Ten out of thirteen aircrew who suffered from idiopathic spontaneous pneumothorax were kept on flying status after successful pulmonary surgery. The time of grounding ranged from 3 to 14 months.

Author

**N74-13784** Centre d'Essais en Vol, Bretigny-sur-Orge (France)  
**AIRCREW'S FITNESS FOR FLYING DUTIES AFTER VERTEBRAL FRACTURES AND SPINAL SURGERY [APTITUDE AU VOL DU PERSONNEL NAVIGANT APRES FRACTURES DU RACHIS ET INTERVENTIONS CHIRURGICALES SUR LA COLONNE VERTEBRALE]**

Roland-Paul Delahaye (Service de Sante pour l'Armee de l'Air, Paris), Robert Auffret, Jacques Mine (Hopital Begin, Saint-Mande), and Pierre-Jean Metges (Hopital Begin, Saint-Mande) In AGARD Pathophysiol. Conditions Compatible with Flying Oct 1973 7 p refs. In FRENCH (For availability see N74-13784 05-04)

Some features of flying such as vibration and accelerations, may sensitize the spine, ejection seat bail-out and/or crash can result in more or less deleterious spine injuries and fractures. After every accident, spinal disorders, or spinal surgery aircrew must be reexamined for flying fitness. After fractures it is of the utmost importance to determine the degree of spinal stability or instability, such as after spinal disorders e.g. osteoarthritis or arthrosis, or surgery (laminectomy), or surgery for disc hernias or spondylolisthesis. Special emphasis has been given to the evaluation of aircrew with repeated vertebral traumas on damaged spines and fractures after surgery for spinal conditions. Author

**N74-13795** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**THE RISK OF MINOR SPINAL ABNORMALITIES IN AIRCREWS: EVALUATION OF EJECTION CASES**

A Beck In AGARD Pathophysiol. Conditions Compatible with Flying Oct 1973 4 p refs (For availability see N74-13784 05-04)

An attempt has been made to determine pre-existing spinal abnormalities in aircrew which may have had a detrimental effect on the traumatic events, retrospectively, i.e. after fracture of the vertebral body had occurred. The collection of these findings was compared with cases of ejection seat bailouts without injuries or fractures in order to recognize morphological alterations which may possibly be conducive to fracture. Author

**N74-13796** Advisory Group for Aerospace Research and Development, Paris (France)

**AERONAUTICAL REHABILITATION OF FLYING PERSONNEL SUFFERING FROM ACUTE PSYCHIATRIC DISTURBANCES [LA REHABILITATION AERONAUTIQUE DES MEMBRES DU PERSONNEL NAVIGANT AYANT PRESENTE DES TROUBLES PSYCHIATRIQUES AIGUS]**  
 R Gelly and J C Hadni In AGARD Pathophysiol. Conditions Compatible with Flying Oct 1973 9 p In FRENCH (For availability see N74-13784 05-04)

Acute psychiatric symptoms combined with behavioral anomalies are normally aeromedical reasons for rejection both from flying and from regular military service. Based on an extensive case report survey, it can be demonstrated fairly clearly that such decisions are not always justified. Each case must be considered from an individual viewpoint since in many cases psychiatric symptoms and behavioral anomalies cannot be diagnosed with absolute certainty. In particular, some obviously serious crises merely reflect individual difficulties in the course of adaptation. Any decision must therefore be based on a diagnosis of the personality structure and personality tests must be considered a major element of psychopathological diagnosis. Psychotherapy can bring to a satisfactory solution some psychiatric syndromes which have been in the past considered irreversible. However, psychotherapy in order to be successful must be associated with concurrent actions both in the professional environment and in further flying training, etc. Under these conditions the rehabilitation for flying duties of aircrew who had acute psychiatric troubles, possible. Author

**N74-13797** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**IMPORTANCE OF THE 4 - 5 c/sec RHYTHM IN THE EEG TO DETERMINE MILITARY FLYING FITNESS**

H Oberholz In AGARD Pathophysiol. Conditions Compatible with Flying Oct 1973 3 p refs (For availability see N74-13784 05-04)

The 4 - 5 c/sec rhythm is probably a genetically determined

variant of the normal EEG which may easily be misinterpreted as a fairly serious general alteration of the EEG. In order to differentiate between similar EEG patterns, the characteristics of this EEG-variant and the special mode of EEG registration were discussed and appropriate EEG's demonstrated. From the literature, the results of family examinations including possible causes of these EEG-variants were presented. Psychological peculiarities in persons showing this EEG variant were emphasized and criteria for the assessment of military flying fitness and preventive measures were proposed. Cases found were analyzed and the procedures applied to variant carriers presented. Author

**N74-13798** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

**OPHTHALMOLOGICAL SUPERVISION OF DIABETIC FLYING PERSONNEL [SURVEILLANCE OPHTHALMOLOGIQUE DU PERSONNEL NAVIGANT DIABETIQUE]**

J P Chevaleraud and G Perdriel In AGARD Pathophysiol. Conditions Compatible with Flying Oct 1973 5 p In FRENCH (For availability see N74-13784 05-04)

With reference to diabetes mellitus, the ophthalmologist's role can be twofold, through his special examinations he can detect this disorder very early and he can monitor its different forms, its several steps of evolution, and its implications for flying fitness. Based on broad clinically and functionally oriented knowledge and electrophysiological experience, some interesting proposals for the evaluation of aircrews who suffer from different forms of diabetes mellitus are reported. Author

**N74-13799** School of Aerospace Medicine, Brooks AFB, Tex. Aerospace Medical Div

**MANAGEMENT OF GLAUCOMA IN AN AGEING FLYING POPULATION**

Thomas J Tredici, James L Mims III, and James F Culver In AGARD Pathophysiol. Conditions Compatible with Flying Oct 1973 3 p refs (For availability see N74-13784 05-04)

Ageing has definite and certain predictable effects on the visual apparatus. Loss of accommodation with age hampers important visual tasks in the cockpit. Disease processes that are common in any population will eventually also affect the flyer. The occurrence of narrow angle glaucoma in the flying population is so small that it is insignificant, however, with relative maturation of a flying force a 2 to 3 percent figure does become significant. Glaucoma strikes a flyer after a great deal of time and money have been expended in his training and when his experience could be utilized to the maximum. Medical grounding of a significant number of experienced flyers can be considered a loss. Many flyers with increased intraocular pressure have been retained on flying status by a rationale of diagnosis and treatment. The visual effects of drugs utilized in the treatment of glaucoma have been evaluated. Presently only intraocular tension lowering drugs that do not effect visual function are being used. Author

**N74-13800** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

**CURRENT ASPECTS OF COCHLEAR FUNCTION APPLIED TO FLYING PERSONNEL [ASPECT ACTUEL DE LA FONCTION COCHLEAIRE CHEZ LE PERSONNEL NAVIGANT]**

P Blanc and J Bastien (DCSSA, Paris) In AGARD Pathophysiol. Conditions Compatible with Flying Oct 1973 3 p In FRENCH (For availability see N74-13784 05-04)

This 9-years survey is based upon 6024 audiograms of flying personnel who have been rated for at least two years. The results of this investigation can be summarized as follows: (1) Any barotrauma on the middle ear may be neglected, an air passenger who has had stapedectomy for otosclerosis may travel by air without any risk; (2) occupational deafness was not found in flying personnel under investigation; (3) hearing discrimination deficits were found in some individuals since the aviation operational environment stresses aircrew by its considerable noise levels and (4) 12 aircrew with intact ear drums were found to be suffering from moderate conduction deafness and presenting the classic otosclerotic syndrome. Two of them underwent cochlear

surgery and have flown to date 1 000 flying hrs each. The audiometric results produced by surgery remained excellent.

Author

**N74-13801** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**PURE TONE HEARING LOSSES IN PILOTS OF VARIOUS AIRCRAFT, AGE AND FLYING TIME AND ITS SIGNIFICANCE FOR INFLIGHT SPEECH COMMUNICATION**

G. H. Froehlich. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 4 p. (For availability see N74-13784 05-04)

The punch cards of 2000 pilots investigated in 1971 have been separated into 4 groups of flying time respectively age, subdivided into pilots of jet aircraft, piston engine aircraft and helicopters. High tone hearing losses were increasing with age and flying time and in helicopter pilots more rapidly than in pilots of the other types of aircraft. A number of pilot's speech audiograms have been investigated. The intelligibility scores of hearing losses above 3000 Hz were excellent and there are no problems with inflight speech communications. Hearing losses above 2000 Hz resulted in intelligibility scores of 72% at low and 85% at medium speech levels. Less than 10% of the pilots above 45 years of age had hearing losses above 1500 Hz. At medium speech levels they obtained only a score of 70%. 100% are frequently not reached even with high speech levels. Together with the masking effect of inflight cabin noise, voice communication might be endangered, especially if the attenuation characteristics of headsets and flying helmets are poor. In these cases, the use of properly fitting headgear is especially important to insure a favorable noise to speech ratio.

Author

**N74-13802** Hopital d'Instruction des Armees, Versailles (France)

**PROTEINURIAS IN FLYING PERSONNEL (PROTEINURIES ET PERSONNEL NAVIGANT)**

G. Leguay. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 12 p. In FRENCH (For availability see N74-13784 05-04)

Proteinurias have been found much more frequently among air transport aircrew than in fighter pilots. More than 50% of all cases have been observed in aircrew between 20 and 25 years of age which is obviously caused by the age dependant incidence of the orthostatic proteinuria. Chronic proteinurias are in most instances caused by chronic glomerulopathies. If this condition is clinically stabilized, it may be considered compatible with flying. Clearance impairment, however, necessitates a special diet, and the existence of a marked hypertension as well as the incompatibility with vaccinations indicates grounding of these aircrew. To verify the interaction of proteinurias and flying, several individuals were exposed to acceleration forces on the human centrifuge. No significant changes of proteinuria were observed during or after the centrifuge rides. However, barometric stresses which occur when flying at different altitudes may be considered dangerous since these barometric pressure differences can exacerbate infectious lesions in ENT areas.

Author

**N74-13803** School of Aerospace Medicine, Brooks AFB, Tex. **THE OCCURRENCE OF HYPERLIPIDEMIA IN FLYING AND NONFLYING SUBJECTS OF THE USAFSAM CARDIOVASCULAR DISEASE STUDY**

Dale A. Clark, Kenneth A. Narahara, and Margaret E. Allen. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 6 p. refs. (For availability see N74-13784 05-04)

The subjects of a cardiovascular disease study were separated into flying and non-flying groups, and the occurrence of elevated lipid levels in these groups was tabulated. The question of interest was whether the stresses of flight elevate serum cholesterol and predispose pilots to the development of atherosclerotic heart disease. None of the percentages obtained in this investigation differ significantly between the two groups. These data therefore indicate that the stresses associated with flying have no more effect on serum lipids than do the stresses

experienced by a group of non-flying officers. A corollary inference is that the prognostic significance of a given serum lipid level is the same whether observed in a flying or a non-flying officer.

Author

**N74-13804** Advisory Group for Aerospace Research and Development, Paris (France)

**THE PROBLEM OF DIABETES MELLITUS IN AVIATION MEDICINE**

Gerhard Renfle. In its Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 7 p. refs. (For availability see N74-13784 05-04)

Problems in aviation medicine which diabetes mellitus raise regulations, waiver, diet, and hypoglycemic agents, are discussed. While the incidence rate is relatively low in student pilots, a higher number of cases is found during follow-up examinations among experienced senior or command pilots. Onset at age 20 to 40 may have the course of either juvenile or adult type. Annual evaluation of carbohydrate metabolism with a standard glucose tolerance test should be mandatory for every military or commercial pilot, and every private pilot after age 40. As sulfonylureas may cause hypoglycemia, any antidiabetic therapy should not be considered compatible with flying duties. Individuals with decreased carbohydrate metabolism tend to hypoglycemic reactions especially in hazardous situations or fasting periods. Waivers should be granted only for diabetic pilots whose carbohydrate metabolism is fully controlled with diet, confirmed by daily testing of urine and frequent postprandial blood sugar examinations. A case report illustrates the fluctuating and reversible course of an incipient diabetes and its effective management in a highly motivated and cooperative senior pilot.

Author

**N74-13805** School of Aerospace Medicine, Brooks AFB, Tex. **THE REPEATABILITY OF AN ABNORMAL 2-HOUR GLUCOSE TOLERANCE TEST**

J. F. Trabai, R. G. Troxler, and M. C. Lancaster. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 3 p. refs. (For availability see N74-13784 05-04)

The diagnosis of diabetes mellitus not only implies a chronic abnormality of carbohydrate metabolism and an increased risk of premature vascular disease, but in the flyer, this diagnosis implies an increased risk to flying safety by reason of physical performance degradation. The glucose tolerance test (GTT) is the accepted standard for the diagnosis of nonmanifest diabetes. A study of the repeatability of the 2-hour GTT was carried out in 162 flyers who had an initial GTT and a repeat GTT from 6 to 24 months later. Of those initial tests considered abnormal, 55 to 60% reverted to normal on the repeat test. The repeatability of the GTT varied with the criteria used and with the number of points on the GTT curve that was considered. The effects of stress on glucose metabolism and the results of the modification of the criteria for the diagnosis of diabetes are discussed. The results of this study illustrate the importance of basic definitions of diagnostic criteria for diseases which have a long term effect on the health of the flying population.

Author

**N74-13806** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**GERMAN AIR FORCE EXPERIENCES WITH CERTAIN CRITERIA FOR GRANTING A WAIVER**

Guenther Schirrmann. In AGARD Pathophysiol. Conditions Compatible with Flying. Oct. 1973. 4 p. refs. (For availability see N74-13784 05-04)

During a period of 13 years there were 28,699 periodic physical examinations of aircrew with 602 granted waivers. These medical waivers were primarily granted in the disciplines of ophthalmology and internal medicine and seem to be justified even after a critical review. Prerequisite to this procedure is not only a profound medical knowledge and know-how, but also comprehensive flight surgeons' experience. A correlation of accidents/incidents caused by pilots with and without waivers indicates practically identical findings while the aircraft accident rate was 3.76% for pilots flying without a waiver, it was 3.45% for pilots flying with a waiver and is therefore identical. An analysis of aircraft accidents involving the waiver group revealed

no evidence indicating that waivers are a triggering or contributing factor in accidents. The procedure seems to be sufficient to eliminate all flying safety risks. Author

**N74-18778** Advisory Group for Aerospace Research and Development, Paris (France).

**CLINICAL PSYCHOLOGY AND PSYCHIATRY OF THE AEROSPACE OPERATIONAL ENVIRONMENT**

P. J. O'Connor, ed. (Roy. Air Force Central Med. Est.) Dec. 1973 88 p refs Presented at AGARD Aerospace Med Panel Specialists Meeting, Soesterberg, Netherlands, 6 Sep 1973 (AGARD-CP-133) Avail NTIS HC \$8.50

Stresses inherent in the military aircrew role are summarized. Summary data cover life stresses, relationship of domestic stress to operational efficiency, and motivation. Data are also given on structural anomalies of the brain and its effects on flying and phobic flight reaction. Several methods of treating psychiatric illness are included. For individual titles, see N74-18780 through N74-18791.

**N74-18780** Gaustad Mental Hospital, Oslo (Norway) EEG Research Inst.

**MENTAL AND PHYSIOLOGICAL ENVIRONMENTAL REQUIREMENTS IN MANNED FLIGHTS**

C W Sem-Jacobsen In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 8 p refs (For availability see N74-18779 10-04)

A study was made of the training and maintenance of today's pilot with respect to his physiological and mental environment. Special attention was placed on a complete monitoring of pilots under operational conditions to map out his tolerance and requirements for full efficiency. E H W

**N74-18781** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**FEAR OF FLYING AND ITS TREATMENT**

K. Gerbert and H. Oberholz In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 6 p refs (For availability see N74-18779 10-04)

A clinical effort was made to treat and return to flying status, pilots in whom psychic, performance, and behavioral irregularities were cited. Particular attention was given to pilots with fear of flying. Treatment was based on quasi-therapeutic interviews, conflict centered counseling, physical exercise therapy, and individually directed flying rehabilitation programs. E H W

**N74-18782** Royal Air Force Central Medical Establishment, London (England)

**RESULTS OF BEHAVIOUR THERAPY IN FLYING PHOBIA**

P. J. O'Connor, J. A. Lister, and J. W. Rollins In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 3 p (For availability see N74-18779 10-04)

The treatment of military crews and pilots for flying phobia by behavior therapy is discussed. Treatment was divided into three series. In series 1 seven cases were treated. Only men who were highly motivated towards military flying and possessed a robust personality were selected. Sixteen consecutive cases were treated in Series 2. No selection was made, all personnel diagnosed as having flying phobia were admitted for treatment. After evaluating the results it was decided to revert to treating select cases. Series 3 had eight cases. All men selected because they had good prognosis for recovery. It was concluded that there is a better chance of improving a pilot with flying phobia to the point where he can fly training type aircraft than for getting him well enough to return to high performance aircraft. Author

**N74-18783** Royal Air Force, Farnborough (England)  
**ASSESSMENT OF BEHAVIOUR THERAPY IN THE TREATMENT OF FLYING PHOBIA**

A. B. Goorney In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 7 p refs (For availability see N74-18779 10-04)

An accurate assessment of the effectiveness of behaviour

therapy (or of any other therapeutic method) in the treatment of flying phobias is difficult due to lack of information. Nevertheless there is evidence to suggest that for selected cases behaviour therapy may be an effective treatment with a high percentage returned to full flying. Selection should be restricted to cases in whom anxiety is limited to a part of the total flying environment (focal anxiety). A mixed technique is suggested in which emotional control is regained through non-reinforcement. Author

**N74-18784** Royal Air Force Central Medical Establishment, London (England)

**DEPRESSION IN AIRCREW**

P. J. O'Connor, A. W. Black, and J. W. Rollins In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 2 p (For availability see N74-18779 10-04)

Treatment and disposal of depressive illness in air crews are analyzed. Common etiological factors of the illness are listed. Author

**N74-18785** Centre Medical de Psychologie Clinique de l'Armée de l'Air, Paris (France)

**CLINICAL STUDY OF LOSS OF AERONAUTICAL MOTIVATION [ETUDE CLINIQUE DES PERTES DE MOTIVATION AERONAUTIQUE]**

R. Gelly In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 4 p In FRENCH (For availability see N74-18779 10-04)

Factors accountable for the loss of motivation or interest in flying by military crew trainees are examined. Some of the motivation loss was attributed to social and flight stress, expectations of trainee not met during training period, and psychological and psychiatric aptitude of trainee is exceeded by training. Transl. by E.H.W.

**N74-18786** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**PARTIAL CEREBRAL HYPOXIC ATTACKS IN PILOTS AS CAUSE OF HYPOXIA INCIDENTS**

H. Oberholz In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 4 p refs (For availability see N74-18779 10-04)

Screening methods for detecting and avoiding as well as determining the causes of cerebral hypoxic attacks in pilots during flying missions are introduced. Special attention was given to anomalies and variants of brain arteries, especially the Circle of Willis as the possible source of the attacks. Two case histories along with symptoms of the attacks are outlined. It was concluded from the data that the Circle of Willis in combination with hypoxia, low G forces, mental stress, extreme heat, and any kind of exhaustive or vestibular stimuli cause cerebral attacks. E H W

**N74-18787** School of Aerospace Medicine, Brooks AFB, Tex. Neuropsychiatry Branch

**CHARACTERISTICS OF LIFE STRESS IN A POPULATION OF MILITARY AVIATORS**

Carlos J. G. Perry and John W. Gaines In AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 2 p (For availability see N74-18779 10-04)

A description is given of a military aviator population with respect to the occurrence of life stress events in its individual members. Questionnaires, inventories, and checklists were deliberately avoided to emphasize a broad range of freedom for the interviewer. During the course of such an interview life stress events were discovered that are missed by questionnaires. This was especially true of anniversary stress which was revealed only through persistent, patient questioning. A total of 320 life stress events were found during the study. Job stress was most frequently represented with personal health, marital, and parental relationships following in order of frequency. Author

**N74-18788** Centre de Medecine Aeronautique, Brussels (Belgium)

**SELECTION OF STUDENT PILOT CANDIDATES OF THE**

**BELGIAN AIR FORCE BY PSYCHOMOTOR TESTS [SELECTION DES CANDIDATS ELEVES-PILOTES DE LA FORCE AERIEENNE BELGE PAR DES TESTS PSYCHO-MOTEURS]**

J. Clement and J. Pardaens *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec 1973 11 p refs *In* FRENCH (For availability see N74-18779 10-04)

The predictive value of psychometric tests in investigating a sample of 413 student pilots and determining their fitness as future pilots is reported. The tests are used in conjunction with a linear method to select candidate student pilots. Results of the tests are given in tables and graphs. Transl. by E.H.W.

**N74-18782** Centre de Medecine Aeronautique, Brussels (Belgium).

**PERSONALITY TRAITS AND FLIGHT APTITUDE [TRAITS DE PERSONNALITE ET APTITUDE AU VOL]**

VanMassenhove and Flion *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec 1973 8 p *In* FRENCH (For availability see N74-18779 10-04)

Stonni's psychological testing method was used to determine the fitness and flight aptitude of student pilots. In particular an attempt was made to determine personality traits and correlate them with flight aptitude. Seventy nine student pilots were tested using two groups designated as Group A and Group B. Group A students were just entering training and Group B students were ending their training. A comparison was made of the two Groups' response to different flight environments. Detailed results are given in graphs. Transl. by E.H.W.

**N74 18790** Italian Air Force Aerospace Medical Center, Rome.

**IN-FLIGHT PSYCHIC LOAD IN STUDENT-PILOTS, EVALUATED BY MEANS OF VANIL MANDELIC ACID (VMA) CHANGES IN URINARY EXCRETION**

G. Paolucci and G. Blundo *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec 1973 2 p refs (For availability see N74-18779 10-04)

Sixty four air cadets were tested for in-flight psychic load and anxiety crises by vanil mandelic acid content in the urine. The tests were made in an effort to determine possible preexisting stress and the measurement of its degree. It was suggested that VMA content is proportional to the amount of stress, and that this method should be included in tests for selecting pilots.

Author

**N74-18791** Royal Netherlands Air Force the Hague.  
**INFLUENCE OF SOCIAL/RELATIONAL FACTORS ON OPERATIONAL FLYING CAPACITY: A SYSTEM-ORIENTED APPROACH**

H. Merkus and J. J. VanderMaas *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec 1973 5 p refs (For availability see N74-18779 10-04)

The effectiveness of the psycho-social approach to treating military pilots with psychological problems or symptoms of such problems is examined. After an explanation about the viewpoints of the psycho-social model, a description is given of how the model is made applicable in psychiatric practice. Three case histories are presented to illustrate the use of the model.

Author

**N74-22727#** Advisory Group for Aerospace Research and Development, Paris (France).

**MANUAL OF AERONAUTICAL MEDICINE AND APPLICATION TO NAVIGATION PERSONNEL [MANUEL DE MEDECINE AERONAUTIQUE A L'USAGE DU PERSONNEL NAVIGANT]**

T. G. Dobie (RAF) Dec 1972 280 p *In* FRENCH (AGARDograph-154(FR), AGARD-AG-154(FR)) Avail NTIS HC \$17.00

Diverse aerospace medical data are summarized. Summaries cover mental and physical health, respiration and circulation, hypoxia prevention, pressure reduction effects, and effects of extreme heat on the body. Data are also given on air sickness,

noise and vibration, cabin pressurization and rapid decompression, vision, and survival. Several other related topics were also summarized. Transl. by E.H.W.

## 05 BIOTECHNOLOGY

Includes life support systems, human engineering, protective clothing and equipment, crew training and evaluation, and piloting. For related information see also: 04 Biosciences.

**N71-22301#** Advisory Group for Aerospace Research and Development, Paris (France).

**PHYSICAL FITNESS IN FLYING INCLUDING THE AGING AND AGED AIRCREW**

H. W. Kirchhoff, ed. Mar 1971 173 p refs Presented at the Specialist Meetings of the Aerospace Med. Panel of AGARD, Garmisch-Partenkirchen, West Germany, 21 - 22 Sep 1970 (AGARD-CP-81-71) Avail NTIS

Physical fitness and pilot performance in connection with physiological training are considered. A variety of the symptoms of the aging process are described and their effects on the performance of flying personnel are considered. For individual titles see N71-22302 through N71-22321.

**N71-22302#** Clemenshospital, Muenster (West Germany)

**PHYSICAL FITNESS AND FLYING**

Alfred Koch / In AGARD Phys Fitness in Flying including the Aging and Aged Aircrew Mar 1971 16 p refs (See N71-22301 11-05)

Avail NTIS

The term fitness is described and defined as a state which characterizes the degree to which the human organism is able to function. Measurements of physical fitness aptitude and of the factors that impair or improve fitness are discussed in relation to flying aircrews. G G

**N71-22303#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

**METHODS OF MEASURING PHYSICAL FITNESS**

H. W. Kirchhoff / In AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 5 p (See N71-22301 11-05)

Avail NTIS

Single stage, non-steady state, submaximal exercise procedures are commonly used in diagnostic and functional testing. The principal modes of imposing the workload are step climbing, bicycle ergometer riding and treadmill walking. These tests are generally available and safe. Despite many real and hypothetical deficiencies, they may yield, when standardized, qualitative and quantitative information of considerable value to individual clinical evaluations and to group comparisons. Steady state submaximal exercise tests determine a great number of values ( $V_{sub O_2}$ ,  $V_{sub CO_2}$ , RQ,  $V_{sub E}$ , specific ventilation, oxygen pulse, pulse rate, blood pressure and the ECG). Vite maxima tests are utilized to determine the maximum values of oxygen consumption and the physical working capacities. Author

**N71-22304#** Army Research Inst of Environmental Medicine, Natick, Mass. Military Ergonomics Lab

**PHYSICAL FITNESS, FLIGHT REQUIREMENTS AND AGE**

Ralph F. Goldman / In AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 9 p refs (See N71-22301 11-05)

Avail NTIS

Muscular strength, cardio-respiratory capacity and relative body weight are frequently used criteria of physical fitness. These different aspects of fitness all alter predictably with age and can be altered by training. Considering the physical work involved in flight, it seems appropriate to consider to what degree physical

fitness -- and which aspects of it -- should be important to an aircrew. Excess weight may require premature replacement of an individual because of the decreased longevity associated with being overweight, but should not hinder flight performance as long as the man fits into his workspace, and agility and reach are unimpaired. The energy cost of flying only averages 125 kcal/hr and even an average 65 year old in fair condition has a maximum work capacity at least 3 times that. Finally, the muscular forces required to fly modern aircraft are minimized by electro-mechanical control systems. Author

**N71-22305#** Canadian Armed Forces Inst. of Environmental Medicine, Toronto (Ontario)

**PHYSICAL FITNESS AS PART OF AIRCREW TRAINING**

C. L. Allen / In AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 9 p (See N71-22301 11-05)

Avail NTIS

Physical fitness development of aircrew candidates in the Canadian Forces is an integral part of their training. Schedules have been established and promulgated for all levels of training from newly enrolled cadets to the advanced flying school stages. While all of the standard elements of physical conditioning, such as calisthenics, resistance training and sports activities are included, the emphasis is on cardio-respiratory development. Regular assessments of candidates are carried out, using the 12-minute distance as the vehicle for testing. All personnel are expected to maintain a good category, i.e. at least 1.50 miles in 12 minutes for ages under 30 years with a suitable reduction for older candidates. Author

**N71-22306#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Lind Codesberg (West Germany) Institut fuer Flugmedizin

**PHYSICAL TRAINING STATUS IN RELATION TO STRESS TOLERANCES**

H. M. Wegmann and K. E. Klein / In AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 11 p refs (See N71-22301 11-05)

Avail NTIS

The influence of physical fitness on stress tolerance was studied by comparing two different groups of subjects, one group including 11 highly trained athletes and the other group consisting of 11 untrained and unadapted students. Both groups were uniformly subjected to hypoxia, acceleration, exercise, and orthostatic stress, applying maximal loads for evaluating tolerances and submaximal loads for studying cardiovascular and hormonal stress responses. In summarizing the results the following conclusions were obtained. A better physical fitness does not imply higher tolerances to stressors other than exercise. There is no indication which supports the idea of an improvement of human tolerance to environmental extremes by physical exercise training. Author

**N71-22307#** German Air Force, Porz-Wahn (West Germany)

**PHYSICAL CONDITIONING TRAINING AND FITNESS TEST OF GERMAN AIR FORCE AIRCREWS**

W. Hill / In AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 7 p ref (See N71-22301 11-05)

Avail NTIS

Physical conditioning training and fitness tests for German Air Force flying crews are considered as an alternative to the United States of America's Aerobics Physical Fitness Program. The purpose of both programs is to improve the physical conditions of aircrew members until the levels of optimum fitness are attained and thereafter to maintain these high levels for as long as possible. There are, however, essential differences in the application of the two methods. Author

**N71-22308#** Army Personnel Research Establishment, Blythe (England)

**EXERCISE TOLERANCE OF MILITARY PERSONNEL**

M F Haisman /In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 6 p refs (See N71-22301 11-05)

Avail NTIS

The exercise tolerance of British Army personnel has been investigated by means of estimates of maximal oxygen intake ( $\text{Vo}_2 \text{ max}$ ) and the Harvard step test.  $\text{Vo}_2 \text{ max}$  was estimated from heart rates, recorded during performance of standardized exercises on stepping stools or bicycle ergometers. About 650 men have been included in the study. The results have indicated that estimated  $\text{Vo}_2 \text{ max}$  provided an index of fitness suitable for application to large groups of men, in that it was reproducible, and sensitive in respect of separating groups of trained and untrained men and in detecting the improvements in fitness associated with intensive physical training. The Harvard step test results were of broadly similar pattern to the  $\text{Vo}_2 \text{ max}$  results but reproducibility was poorer. Men with a high body fat content showed a marked tendency to have a low  $\text{Vo}_2 \text{ max}$ . Author

**N71-22309#** Strasbourg Univ (France) Inst Dentaire  
**AERONAUTICAL FACTORS AND TOOTHACHE  
INCIDENCES DURING FLIGHT [FACTEURS  
AERONAUTIQUES ET INDIVIDUELS DES DOULEURS  
DENTAIRESEN VOL]**

R Frank, J M Debruge, and A M Flister /In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 8 p refs. In FRENCH-ENGLISH summary. Prepared jointly with Centre d'enseignement et de Rech de Med Aeron (See N71-22301 11-05)

Avail NTIS

A recent investigation made on 230 conventional and jet aircraft pilots in the French Air Force has provided a comprehensive picture of the incidence of toothache in flight and of its favoring factors. Over a year of observations, it was found that 65.2% of the investigated pilots suffered from toothaches in flight. Pains developed according to a rather characteristic process during the various phases of flight: (1) chronic pulpitis induces short lived, progressively appearing throbbing type pains which appear mostly during climbs; (2) wisdom teeth and periapical reactions on mortified teeth or improperly stopped radicular canals rather induce pains during descents; and (3) periapical granulomas become painful in cruise flights without any marked speed variations; the induction of such neuralgias is related, among other reasons, to the vibrations experienced by the pilot. Author

**N71-22310#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**COMBINED ENVIRONMENTAL, EMOTIONAL, AND  
PHYSICAL ACTIVITY THERAPY: A MODERN PREVENTIVE  
AND RECONDITIONING PROGRAM**

J D Meyer-Erkelenz /In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 14 p refs (See N71-22301 11-05)

Avail NTIS

Physical exercise training combined with environmental, emotional and Terrain Kur effects is an optimal therapy in preventing and reconditioning treatment of civilization and hypokinetic diseases, because a predominantly neuro-vegetative alteration in the whole body takes place. The results on heart, respiration, muscles, vascular, metabolic, hormonal, CNS and other organic systems are detailed. The physical fitness of German Air Force pilots is maintained or increased by (1) exercise training designed for individual performance, and (2) the active cure treatment with multiple additional therapeutic elements, e.g. sauna, hydrotherapy, skin brush massage, etc. The gymnastic exercises are described and illustrated. Positive success is demonstrated in measurable facts and stress tests before, during and after 4 weeks of cure. Author

**N71-22311#** Canadian Armed Forces Inst of Environmental Medicine, Toronto (Ontario)

**AEROBIC CAPACITY SURVEY: CANADIAN FORCES  
PERSONNEL**

C L Allen /In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 4 p refs (See N71-22301 11-05)

Avail NTIS

The maximum oxygen intake of a representative sample of 1004 Canadian Forces personnel has been determined. The daily activity patterns as well as heights, weights, skinfold thicknesses and smoking histories were also recorded. The values for aerobic power are similar to those reported for other North American groups in the same age range. The levels of daily activities and smoking histories have measurable effects on the endurance fitness of these personnel. Author

**N71-22312#** Erlangen-Nuremberg Univ (West Germany)  
**FUNDAMENTAL SUBJECTS OF GERONTOLOGY AND  
PARTICULARITIES OF GERIATRICS**

R Schubert /In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 4 p (See N71-22301 11-05)

Avail NTIS

The biological aspects of senescence are considered. For the purpose of performing systematic work in this field it is necessary to differentiate and clearly define the various forms of calendar based or chronological senescence. Besides this form of senescence governed by the unbiased time factor, there is also the most important form of biological senescence, including the two sub-forms of physiological and psychological aging. The psychological chronograph records the personal time of an individual, the decisive factor being the experiences the individual has lived through during that period. Physiological senescence is determined by the development, growing and aging of morphae and the functions of organs. The most rigorous criteria are imposed by calendar time, which sets absolutely unbiological upper and lower age limits. The problem of flexible age limits is once more becoming most important. Author

**N71-22313#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**PHYSICAL ACTIVITY AND AGING**

H W Kirchhoff /In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 5 p (See N71-22301 11-05)

Avail NTIS

There appears to be acceptable evidence that exercise does affect biochemical and physiological parameters related to ischemic heart disease and to the myocardium itself. It is remarkable that a physical fitness program of the German Institute of Aviation Medicine had an extraordinarily good effect on blood pressure, ECG and other parameters. Since this program was begun, increases in blood pressure have been considerably less frequent. There occurred a lowering of the heart rate at rest and during exercise, an improvement of orthostatic tolerance, normalization of exercise induced hypoxic electrocardiographic changes at low oxygen pressure and an increase of oxygen uptake, respiratory volume and oxygen pulse during physical effort. These data corroborate the concept of a preventive and rehabilitative value in physical and environmental-emotional conditioning programs. The training program provides objective evidence for a clearly favorable influence of conditioning periods on cardiovascular function of the aging pilot. Author

**N71-22314#** Naval Aerospace Medical Inst, Pensacola, Fla  
Naval Aerospace Medical Research Lab

**THE THOUSAND AVIATORS: A THIRTY YEAR FOLLOW  
UP**



R. E. Mitchell, A. Graybiel, A. Oberman (Ala. Univ.), and W. R. Harlan (Ala. Univ.) *In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew* Mar. 1971. 5 p. (See N71-22301 11-05)

Avail NTIS

The thousand aviator project is a longitudinal study with the emphasis primarily on defining new physical standards for aviators and secondarily on an epidemiological study of aging. The present report is limited to a discussion of the electrocardiographic and blood pressure findings. Longitudinal changes in the resting electrocardiograms have shown that those individuals with a decrease in QRS amplitude and a leftward movement of the QRS vector appear to have a tendency to develop coronary artery disease. Some of the men in the group have shown a consistent rise in blood pressure, apparently related to weight gain and parental longevity. Otherwise there are no means by which the blood pressure pattern of an aging individual can be predicted. Author

**N71-22315#** Canadian Armed Forces Inst. of Environmental Medicine, Toronto (Ontario)

**MORBIDITY OF AIRCREW IN THE CANADIAN FORCES IN RELATION TO AGE**

W. J. C. Stevenson. *In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew* Mar. 1971. 8 p. (See N71-22301 11-05)

Avail NTIS

One of the factors in the consideration of the aging process in aircrews is the relationship of illness, injury, and physiological incidents. Evaluations of 268 pilots and air navigators, representing 6.8% of the established Canadian aircrew strength, were carried out because individuals either failed to meet prescribed medical standards or else had developed some difficult, obscure or border-line medical problems which raised a question of fitness to continue flying. Data indicate that diseases of the circulatory system were cause for removal from flying duties of the largest number of older aircrew members, while psychiatric disorders resulted in the greatest number of groundings in the younger group. Author

**N71-22316#** School of Aerospace Medicine, Brooks AFB, Tex.  
**THE EFFECTS OF AGING ON BODY COMPOSITION AND EXERCISE PERFORMANCE IN THE USAF AIRCREW POPULATION**

John W. Ord and Malcolm C. Lancaster. *In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew* Mar. 1971. 10 p. refs. (See N71-22301 11-05)

Avail NTIS

Nine hundred seventeen healthy aircrewmembers ranging in age from 25 to 49 years were evaluated for minor medical findings. During the same period, 346 pilots were evaluated as part of the selection process for special projects such as space flight. The differences between the groups and in subgroups according to age in parameters bearing on physical fitness are described. The special project group was more fit than the other normal group as demonstrated by their response to maximal treadmill testing, had a lesser body fat fraction and lower blood lipid and glucose levels. Older subgroups demonstrated lower maximal treadmill exercise performance, had higher body fat fractions and tended to demonstrate higher levels of blood lipids and glucose. Author

**N71-22317#** School of Aerospace Medicine, Brooks AFB, Tex.  
**A COMPARISON OF THE EFFECTS OF EARLY CARDIOVASCULAR DISEASE AND AGING UPON MAXIMAL EXERCISE PERFORMANCE IN THE USAF AIRCREW POPULATION**

Malcolm C. Lancaster and John W. Ord. *In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew* Mar. 1971. 8 p. refs. (See N71-22301 11-05)

Avail NTIS

The influence of early, mild cardiovascular disease upon maximal exercise performance in 544 flyers, ages 40-49 years was considered. There were 300 normal subjects, 64 subjects with non-specific repolarization changes on the electrocardiogram, 114 subjects with hypertension and 66 subjects with coronary heart diseases. The NSTWC and hypertensive groups had significantly higher body fats than normals. There were no significant differences between the disease groups and normals with respect to blood sugar and serum lipids. Both the hypertensive and CHD groups had significantly lower maximal oxygen consumptions and total treadmill times than normals. Systolic blood pressures in all disease groups were significantly higher at rest than in normals. Systolic blood pressure increased as expected in normals and a parallel increase was seen in the disease groups. Diastolic blood pressure was unchanged at maximal exercise in normals, while all disease groups were significantly higher. Blood pressure levels in the hypertensive group were significantly higher at rest than the other disease groups and remained proportionately higher with exercise. Author

**N71-22318#** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

**TRACING OF ARTERIOSCLEROSIS DURING EVALUATION OF FLYING PERSONNEL [DEPISTAGE DE L'ATHEROSCLEROSE DANS L'EXPERTISE DU PERSONNEL NAVIGANT]**

R. Carre, J. Salvagnac, and F. Plas. *In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew* Mar. 1971. 9 p. refs. In FRENCH. (See N71-22301 11-05)

Avail NTIS

Cardiovascular abnormalities in more than 3000 flying personnel were studied during a 12 year period by performing electrocardiographic, cholesterol content, and carotidogrammetric evaluations. It was established that more than 30% of the disabled group had cardiovascular diseases with the greatest number found between 45 to 50 years of age; aging personnel were more accident prone and pilots of the French Air Force were grounded if they showed typical arteriosclerotic symptoms. Also grounded were pilots over 40 years of age with ECG abnormalities. Transl. by G.G.

**N71-22319#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**PSYCHOPHYSIOLOGICAL PROCESSES OF AGING**

H. J. Grunhofer and K. Gerbert. *In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew* Mar. 1971. 7 p. refs. (See N71-22301 11-05)

Avail NTIS

Facts observed so far concerning variations and decrement of cognitive, psychomotoric, and retentive abilities with increasing age are reported. Generally it can be assumed that almost all psychophysical performance functions decrease at the third decade of life. But abilities with increasing age are essentially dependent upon the level of original aptitude, type and extent of experience gained in the course of life, thinking patterns, and trained procedures consolidated through exercise. On the other hand, particular decreasing capabilities can only be compensated by others within certain limits. As a result, adjustment and readjustment to requirements which cannot be met by means of confirmed behavior became increasingly difficult. An analysis of presently used methods to measure flying proficiency in aging pilots is given. Author

**N71-22320#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**HEARING ACUITY IN RELATION TO AGE AND FLYING TIME**

G. R. Froehlich. *In AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew* Mar. 1971. 8 p. (See N71-22301 11-05)

Avail NTIS

The pure tone audiograms of 1024 Air Force pilots and 100 applicants were classified into 3 categories: (Q1) the 25% with best hearing capacity, (Q2) the 50% with medium hearing capacity, (Q3) the 25% with poorest hearing capacity, and S hearing losses of industry population. The evaluation had the following results: (1) pilots classified as Q 1 and Q 2 had a hearing acuity that was slightly better or equal to comparative age groups of a normal industry population, (2) Even in the Q 3 groups with marked hearing losses, the main speech frequencies of 500 - 2000 Hz showed only negligible impairment, (3) the hearing acuity of jet-pilots is slightly better than that of pilots in helicopters and propeller aircraft, and (4) for the decrease in hearing acuity age is more important than flying time. Author

**N71-22321#** Centre de Medecine Aeronautique, Brussels (Belgium)

**LONGITUDINAL STUDY OF SPIROMETER VALUES FOR NAVIGATOR PERSONNEL OF THE BELGIAN AIR FORCE (ETUDE LONGITUDINALE DES VALEURS SPIROMETRIQUES DU PERSONNEL NAVIGANT DE LA FORCE AERIENNE BELGE)**

J. Bende. In: AGARD Phys. Fitness in Flying including the Aging and Aged Aircrew. Mar. 1971. 7 p. (See N71-22301 11-05)

Avail. NTIS

Long term spirometric measurements on Belgian Air Force flying personnel obtained over a period from 5 to 10 years, are evaluated in order to establish the influence of aging on physical fitness concurrent with the process of aging. A new special formula is presented that is applicable for ages 15 through 55 and can be used to predict the developing vital capacity for each individual subject during aging. Transl. by G. G.

**N71-23337#** Advisory Group for Aerospace Research and Development, Paris (France)

**PRINCIPLES OF BIODYNAMICS APPLICABLE TO MANNED AEROSPACE FLIGHT PROLONGED LINEAR AND RADIAL ACCELERATION**

Mar. 1971. 182 p. refs.

(AGARDograph 150. AGARD AG 150.71). Avail. NTIS

**CONTENTS**

1. ACCELERATION TERMINOLOGY. TABLE OF COMPARATIVE EQUIVALENTS. G. J. Pesman. p. 1-6. refs. (See N71-23338 12-23)

2. AN INTRODUCTION TO THE PHYSICS AND PHYSIOLOGY OF ACCELERATION. S. D. Leverett Jr. p. 7-24. (See N71-23339 12-04)

3. THE DYNAMICS OF ROTATION APPLIED TO CENTRIFUGES. R. E. Van Patten. p. 25-36. (See N71-23340 12-23)

4. A SUMMARY OF HUMAN TOLERANCE TO PROLONGED ACCELERATION. A. S. Hyde and H. W. Raab. p. 37-56. refs. (See N71-23341 12-04)

5. DESCRIPTIVE CATALOG OF AEROSPACE MEDICAL BIODYNAMICS FACILITIES IN THE UNITED STATES AND CANADA. C. F. Gell. Naval Aerospace Med Inst. Pensacola, Fla. p. 57-100. (See N71-23342 12-11)

6. BIODYNAMICS FACILITIES IN NATO EUROPEAN COUNTRIES. A. Scano. (Military School of Aviation Med. Rome, Italy) p. 101-124. refs. (See N71-23343 12-11)

7. BIODYNAMICS BIBLIOGRAPHY, 1966-1969. V. L. Jones. NASA, Washington, D. C. p. 125-196. refs. (See N71-23344 12-05)

**N71-23338#** Advisory Group for Aerospace Research and Development, Paris (France)

**ACCELERATION TERMINOLOGY. TABLE OF COMPARATIVE EQUIVALENTS**

G. J. Pesman. In: *Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration*. Mar. 1971. p. 1-6. refs. (See N71-23337 12-05)

Avail. NTIS

Development of vertical or steep landing and takeoff aircraft helicopters and space vehicles has destroyed the comfortable situation in which the vehicle and occupants maintained a fixed relationship. With the advent of these advances it became desirable that essentially two directional terminologies be used, one for the vehicle and another for the occupants. Terms were evolved and as far as possible have been incorporated into revised tables of equivalent terminology for both linear and angular motion. Tables of comparative equivalents are presented which are organized into the form of a statement of the laws of motion. A. L.

**N71-23339#** Advisory Group for Aerospace Research and Development, Paris (France)

**AN INTRODUCTION TO THE PHYSICS AND PHYSIOLOGY OF ACCELERATION**

S. D. Leverett Jr. In: *Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration*. Mar. 1971. p. 7-24. (See N71-23337 12-05)

Avail. NTIS

The history of acceleration and its relation to aviation medicine is reviewed along with a brief discussion of the conventional terminology for describing the vector and the physiological effects and eventual response of the human body to these forces. A. L.

**N71-23340#** Advisory Group for Aerospace Research and Development, Paris (France)

**THE DYNAMICS OF ROTATION APPLIED TO CENTRIFUGES**

R. E. van Patten. In: *Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration*. Mar. 1971. p. 25-36. (See N71-23337 12-05)

Avail. NTIS

An intuitive, graphical, and simplified mathematical treatment is presented on the subject of rotational dynamics as applied to human centrifuges. This approach was taken in order to relieve physicians and medical personnel of the labor required to gain a rigorous insight into the subject and to strip away the non-essentials associated with the classic development. Definitions are provided of the terms associated with the subject as they are commonly used and misused. Coriolis acceleration is discussed and some examples of Coriolis effects are provided. A. L.

**N71-23341#** Advisory Group for Aerospace Research and Development, Paris (France)

**A SUMMARY OF HUMAN TOLERANCE TO PROLONGED ACCELERATION**

A. S. Hyde and H. W. Raab. In: *Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration*. Mar. 1971. p. 37-56. refs. (See N71-23337 12-05)

Avail. NTIS

A summary of data from literature on human tolerance to prolonged acceleration is presented in tabular and graphical form. Standard terminology derived from an AGARD (NATO) agreement on the equivalent of acceleration terminology is given. Most of the graphs present the magnitude of acceleration as an absolute or both an and the duration of the exposure as a separate variable. A separate group of graphs are assembled for each direction of acceleration. Each group of graphs is further divided on the basis of the presentation of a chart, plot, or diagram. The number of subjects used in support of the data, and the number of plots included for each graph, summary of magnitude, duration, and direction of exposure, and the number of subjects used in support of the data, are indicated.

given and a table provided. Each table defines each point on each graph with respect to the following variables: vector magnitude, duration, average onset (G, second), back angle, cause of termination of experimental exposure, trauma, number of subjects involved, countermeasures used, support, restraint, and the reference from which this information was obtained. A L

**N71-23342# Naval Aerospace Medical Inst. Pensacola, Fla.  
DESCRIPTIVE CATALOG OF AEROSPACE MEDICAL  
BIODYNAMICS FACILITIES IN THE UNITED STATES AND  
CANADA**

Charles F. Gell, ed. In AGARD Principles of Biodynamics, Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration. Mar 1971. p. 57-100. (See N71-23337 12-05). Avail. NTIS

A descriptive text and pictorial display are presented of the newest equipment and latest modifications of older equipment used in biodynamic studies conducted in United States Government facilities and in Canadian facilities. Facilities and equipment discussed are located at: (1) Naval Aerospace Medical Institute; (2) Aerospace Medical Research Department; (3) Aerospace Crew Equipment Laboratory; (4) 6570th Aerospace Medical Research Laboratories; (5) 6571st Aeromedical Research Laboratory; (6) United States Air Force School of Aerospace Medicine; (7) Manned Spacecraft Center; (8) Ames Research Center; (9) Civil Aeromedical Institute; (10) National Aviation Facilities Experimental Center; (11) Section of Physiology, Mayo Foundation and Mayo Clinic; and (12) Defense Research Establishment Toronto, Canada. A L

**N71-23343# Military School of Aviation Medicine, Rome, Italy.  
BIODYNAMICS FACILITIES IN NATO EUROPEAN  
COUNTRIES**

Arvid Scario, ed. In AGARD Principles of Biodynamics, Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration. Mar 1971. p. 101-124. refs. (See N71-23337 12-05). Avail. NTIS

Photographs and descriptive texts are presented of facilities and equipment for biodynamic studies and research in France, Italy, and England. A L

**N71-23344# National Aeronautics and Space Administration,  
Washington, D.C.  
BIODYNAMICS BIBLIOGRAPHY, 1966-1969**

Walton L. Jones, comp. In AGARD Principles of Biodynamics, Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration. Mar 1971. p. 125-196. refs. (See N71-23337 12-05). (NASA TM X 67138) Avail. NTIS CSCL 068

This annotated bibliography brings together recent information not available in earlier literature reviews concerning biodynamic research findings. Coverage was international and provides a representative view of current research efforts. The abstracts were taken directly from the initial source documents. The bibliography is divided into six sections: (1) prolonged acceleration (linear and radial); (2) angular acceleration; (3) impact; (4) vibration; (5) combined stresses; and (6) general documents. A L

**N72-14090# Advisory Group for Aerospace Research and  
Development, Paris, France.  
CLINICAL CAUSES FOR GROUNDING**

Heinz S. Fuchs. Nov 1971. 192 p. refs. Presented at the AGARD Aerospace Med. Panel Specialist Meeting, Oporto, Portugal, 21-22 Jun 1971. (AGARD CP 89-71) Avail. NTIS

Papers given at the AGARD Aerospace Medical Panel

Specialist Meeting held in Oporto, Portugal from 21 to 22 June 1971 are presented. The subject was divided into two parts: the general aspects of clinical causes for grounding in the various air forces, and the specific aspects of grounding according to medical specialties. Each paper is followed by a discussion. A technical summary and an evaluation are included at the end. For individual titles, see N72-14091 through N72-14112.

**N72-14091# Italian Air Force Medical Legal Inst., Milan.  
STATISTICAL SURVEY ON THE CLINICAL CAUSES OF  
TEMPORARY GROUNDING AND PERMANENT UNFITNESS  
OF IAF AIRCREWS**

Gaetano Rotondo. In AGARD Clinical Causes for Grounding. Nov 1971. 29 p. refs. (See N72-14090 05-05). Avail. NTIS

An analytical study of the clinical causes that most frequently lead to temporary or permanent loss of fitness among flying personnel was undertaken. A wide statistical survey was made on morbidity, or rather some aspects of morbidity, in the personnel of the Italian Air Force among the various categories or groups of categories connected with the flying service in general and with particular regard to pilots. Such a study was undertaken with the hope of detecting the physio-psychic causes that have most weight and incidence in giving rise to unfitness for military service and for flying. It would then be possible to make practical suggestions in order to reduce the incidence of these causes and their disabling effects. Author

**N72-14092# Royal Naval Air Medical School, Hillhead, (England).  
CLINICAL CAUSES FOR GROUNDING: A REVIEW OF  
ROYAL NAVAL EXPERIENCE, 1962-1970**

I. H. Colley and F. St. C. Golden. In AGARD Clinical Causes for Grounding. Nov 1971. 11 p. refs. (See N72-14090 05-05). Avail. NTIS

The clinical causes for permanent grounding in the British Fleet Air Arm for the period January 1962 to December 1970 inclusive were examined. Clinical groundings constitute 13% of the total groundings for all reasons. Psychiatric illness is responsible for 58% of clinical groundings and was the major cause of wastage in trained aircrews. Author

**N72-14093# Belgian Air Force, Brussels.  
ANALYTICAL STUDY OF THE CAUSES OF MEDICAL  
UNFITNESS OF FLYING PERSONNEL IN THE BELGIAN  
AIR FORCE (ETUDE ANALYTIQUE DES CAUSES  
D'INAPTITUDE MEDICALE DU PERSONNEL NAVIGANT  
DE LA FORCE AERIEENNE BELGE)**

J. Bando and R. Moorthamers. In AGARD Clinical Causes for Grounding. Nov 1971. 11 p. In FRENCH. (See N72-14090 05-05). Avail. NTIS

A comprehensive analysis was made of the causes of temporary and permanent unfitness in cases treated by the ad hoc Medical Commission of the Belgian Air Force from 1965 to 1971. The study concerned 635 subjects, of whom 29.5% had a number of different disabilities. 7.6% of the cases were the object of permanent grounding and 12.9% were permanently limited in their fitness for the air service. 40% of the cases were accident victims. Of 904 disabilities, the pathology of the locomotor system was the most frequent, involving afflictions of both the neuropsychiatric and digestive systems. After eliminating accident cases, the most frequent pathology was of the digestive and respiratory tracts. A study of the correlation between age of the subject and the length of disability as a function of pathological class gave no conclusive results. Transl. by K. P. D.

**N72-14094# Naval Air Station, Norfolk, Va.  
A REPORT OF AVIATOR GROUNDING AND AVIATOR  
SALVAGE IN HIGH PERFORMANCE FIGHTER AIRCRAFT**

Romaine L. Bendixen. In AGARD Clinical Causes for Grounding. Nov 1971. 8 p. refs. (See N72-14090 05-05). Avail. NTIS

The role of the flight surgeon in the United States Navy

and particularly the role of the dually designated physician-pilot is considered in the evaluation, treatment, and disposition of aviators flying in high performance jet fighter aircraft. Personal observations and experiences of the author as a pilot instructor-flight surgeon with a McDonnell F-4 (Phantom II) training squadron form the basis for the presentation and discussion of several cases involving the question of grounding for major clinical reasons. An integral part of these discussions is an attempt to demonstrate the value of the pilot-physician. This report covers a relatively short span of time: October 1967 through July 1969 but is particularly significant in the number of interesting cases that arose requiring evaluation and disposition.

Author

**N72-14095# School of Aerospace Medicine Brooks AFB Tex  
USAF AEROMEDICAL CONSULT SERVICE EXPERIENCE  
IN CAUSES FOR GROUNDING OVER THE PAST FIFTEEN  
YEARS**

Malcolm C. Lancaster. In AGARD Clinical Causes for Grounding Nov 1971. 7 p. refs (See N72-14090 05 05)

Avail NTIS

A marked change in the factors that relate to medical grounding of flyers in the United States Air Force (USAF) has occurred over the past 15 years. The increasing age of the flying population is the major causative factor producing this change. Improved diagnostic techniques and an increase in the fund of information about normals and individuals with early disease also had a significant influence upon both the types of problems evaluated and their disposition. The experience of USAF School of Aerospace Medicine over a period of 15 years is reviewed, and the trends and factors related to medical criteria for grounding USAF flyers are discussed.

Author

**N72-14096# Office of the Surgeon General (Air Force),  
Washington D.C.**

**CAUSES FOR MEDICAL GROUNDING OF PILOTS AND  
NAVIGATORS IN THE UNITED STATES AIR FORCE, 1969**  
Robert A. Farmer and Howard R. Unger. In AGARD Clinical Causes for Grounding Nov 1971. 6 p. (See N72-14090 05 05)

Avail NTIS

Specific indices and measures of the health of USAF-rated officers are computed from biometric data provided by the flight surgeon's medical recommendations. These data are discussed in relation to the health of Air Force flyers and the practice of aerospace medicine in the U.S. Air Force. Similarities and variations of medical practice and management are considered. Comparisons of the rates of removal and noneffective ratios by rating, age, and command are presented.

Author

**N72-14097# Institute of Aviation Medicine, Fuerstenfeldbruck  
(West Germany)**

**Clinical Causes for Permanent Grounding of  
AIRCREW WITHIN THE GERMAN ARMED FORCES**

H. J. Grunhofer and K. R. Mueller. In AGARD Clinical Causes for Grounding Nov 1971. 9 p. (See N72-14090 05 05)

Avail NTIS

All clinical causes for permanent grounding of German armed forces pilots and other aircrew members were examined and analyzed statistically. The causes for medical disqualifications are divided into diagnostic groups or according to specific functions of organs and/or organ systems. Special emphasis is given to waivers and to certain psychological aspects. There were 24,396 physical examinations studied over a period of 11 years.

Author

**N72-14098# Centre Principal d'Expertises Medicales du  
Personnel Navigant Paris (France) Service de Sante des  
Armees**

**STATISTICAL ANALYSIS OF UNFITNESS OF FLYING  
PERSONNEL IN THE FRENCH AIR FORCE [STATISTIQUE  
DES INFIRMITES DU PERSONNEL NAVIGANT DE  
L'ARMEE DE L'AIR FRANCAISE]**

J. Nathie, P. M. Pingannaud, and A. Gibert. In AGARD Clinical Causes for Grounding Nov 1971. 6 p. In FRENCH (See N72-14090 05 05)

Avail NTIS

The physical fitness of flying personnel in the French Air Force is supervised by the Centers for Medical Evaluation of Flying personnel. A general study of 60,811 review evaluations made by the centers from 1960 to 1969 show that among 1400 causes of observed unfitness (temporary unfitness excluded), the most numerous were neuropsychiatric disorders (381 causes) and inadequacy of the visual function (379 causes). These conclusions were made precise in a detailed study of the results in 1969, during which year 72 subjects were declared unfit. It appears that unfitness of neuropsychiatric origin is essentially motivated by psychological or psychosomatic difficulties. The disabilities recorded rarely led to the elimination of flying personnel, the majority being eventually discharged or reclassified into another specialty. The importance of statistical problems is emphasized and their solution by electronic data processing methods is proposed.

Transl. by K. P. D.

**N72-14099# Hellenic Air Force General Hospital, Athens  
(Greece) Dept of Internal Medicine**

**MEDICAL ASPECTS OF GROUNDING AND NONEFFECTIVENESS IN HELLENIC AIR FORCE PILOTS**

C. E. Giannopoulos and H. G. Vissoulis. In AGARD Clinical Causes for Grounding Nov 1971. 5 p. refs (See N72-14090 05 05)

Avail NTIS

Based upon statistics from Greek pilots' individual health files, hospital records, and the Aviation Supreme Medical Board's certifications, a ten-year analytical study of the medical causes of admissions, waivers, suspensions, and permanent groundings is presented. Data on the medical causes for elimination from flying training are also discussed comparatively from an average strength of 542 rated pilots. 24 were permanently grounded for medical reasons. The major cause was due to sensory deficiencies which accounted for 9 groundings or 37.5% of the total. Peptic ulcer disease is the most frequent cause for noneffectiveness and accounts for several permanent groundings. The incidence of coronary heart disease is exceptionally low and should be attributed to the younger age distribution of the surveyed population. The elimination of two cadets for thalassemia minor and the finding of several cases of thalassemia trait among rated pilots brings into focus the problem of thalassemia endemic in certain areas of Greece.

Author

**N72-14100# Naval Aerospace Medical Inst., Pensacola, Fla  
THE US NAVY SPECIAL BOARD OF FLIGHT SURGEONS  
KEEP THEM FLYING SAFELY**

M. D. Courtney. In AGARD Clinical Causes for Grounding Nov 1971. 12 p. (See N72-14090 05 05)

Avail NTIS

In 1957 the United States Navy's Bureau of Medicine and Surgery directed the establishment of the Special Board of Flight Surgeons. This board consists of specialists in aerospace medicine and related fields who can make recommendations concerning the physical qualifications of Navy and Marine Corps aircrew personnel which are necessary for them to continue in duty involving flying. The composition of the Special Board and its method of operation are described, and the kinds of cases referred to it for the past fourteen years and the recommendations made for the disposition of these cases are reviewed.

Author

**N72-14101# School of Aerospace Medicine Brooks AFB Tex  
CHANGING CONCEPTS IN MEDICAL REASONS FOR  
GROUNDING IN THE USAF AEROMEDICAL CONSULT  
SERVICE**

John H. Truhwasser. In AGARD Clinical Causes for Grounding Nov 1971. 9 p. refs (See N72-14090 05 05)

Avail NTIS

Flying safety is the major factor underlying medical decisions regarding a given aviator's fitness to fly. Over the past 15 years medical concepts were modified as experience with an older

population and newer diagnostic techniques was gained. The incidence of degenerative disease has increased parallel with the age of the USAF aircrew member. Increasing emphasis must be placed on the early diagnosis of those conditions that could result in sudden incapacitation. Experience in aerospace medicine is limited to a younger, more healthy population than that found in a hospital. The significance of several electrocardiographic findings usually associated with disease in a sick population is not necessarily of the same importance in the Air Force patient population. Four conditions that were considered representative of significant organic heart disease are considered. These are electrocardiographic repolarization changes, cardiac arrhythmias, acquired bundle branch block, and aortic valvular insufficiency.

Author

**N72-14102\*** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

#### CARDIOLOGIC FINDINGS AS CAUSE FOR GROUNDING

H. W. Kirchhoff and A. Dietz. In AGARD Clinical Causes for Grounding. Nov. 1971. 3 p. (See N72-14090-05-05)

Avail. NTIS

The routine cardiology program performed at the Institute of Aviation Medicine of the German Air Force to determine fitness for military flying duty is described. It is comprised of an overall clinical examination, an electrocardiogram taken at rest and the so-called master two-step test. If required, the physician may order additional electrocardiographic, mechanocardiographic and functional medical tests. Armed forces regulation serves as the criterion for the final assessment and lists all findings which preclude, or render questionable, flying duty.

Author

**N72-14103\*** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

#### NEW FINDINGS CONCERNING THE IMPORTANCE OF ARRHYTHMIAS

A. Dietz. In AGARD Clinical Causes for Grounding. Nov. 1971. 6 p. (See N72-14090-05-05)

Avail. NTIS

Long term electrocardiograms (EKGs) are recorded at the Institute of Aviation Medicine of the German Air Force for any subject showing rhythmic cardiac disturbances. Long term registration is superior to routine EKGs with respect to recording arrhythmias. The advantages and techniques of long term EKGs are considered.

Author

**N72-14104\*** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

#### INCIDENCE OF CORONARY RISK FACTORS IN PILOTS OF THE BUNDESWEHR

Klaus Jung. In AGARD Clinical Causes for Grounding. Nov. 1971. 10 p. (See N72-14090-05-05)

Avail. NTIS

A group of 1000 pilots of different types of aircraft were examined with respect to distribution of various parameters which in extreme cases constituted coronary risk factors: Cigarette consumption, serum cholesterol level, systolic and diastolic blood pressure, physical activity, body weight, vital capacity, fasting blood sugar level, autoneuria, and family predisposition were studied in detail. For the sum of risk factors the distributions were considered for total group, separate age groups, pilots grouped according to types of aircraft flown (total and in separate age groups) and for pilots under 30 years of age grouped according to aircraft flown and training status. Coronary stress is barely increased compared to a normal population. Prop. pilots are at least coronarily jeopardized to the same extent as jet pilots. This is particularly true for older age groups. The greatest increment of psychophysical stress effects on the coronary system occurs between the start of training and the first flying experience, independent of the aircraft type flown.

Author

**N72-14105\*** Office of the Surgeon General (Air Force), Washington, D. C.

#### SUSPENSIONS OF PILOTS AND NAVIGATORS FROM

#### FLYING STATUS FOR MEDICAL REASONS IN THE UNITED STATES AIR FORCE, 1969

Robert A. Farmer and Howard R. Unger. In AGARD Clinical Causes for Grounding. Nov. 1971. 7 p. (See N72-14090-05-05)

Avail. NTIS

The age distribution, causes, numbers, and diagnostic categories of medical suspensions of flying personnel in the U. S. Air Force which occurred in 1969 are discussed. Identification of preventive and clinical medical practices and policies which may prevent or remove the medical cause of the suspension are made possible by the study.

Author

**N72-14106\*** Royal Air Force Central Medical Establishment, London (England)

#### CURRENT NASAL AND AURAL INDICATIONS FOR GROUNDING

P. F. King. In AGARD Clinical Causes for Grounding. Nov. 1971. 6 p. (See N72-14090-05-05)

Avail. NTIS

The current indications for aircrew grounding due to nasal and aural disorders are described. The importance of careful preliminary selection is emphasized. The decreasing incidence of nasal infection was noted, together with the increasing part played by nasal allergy. The question of chronic bronchitis, bronchiectasis and asthma which complicate nasal disease is discussed. Of the commoner aural lesions, otosclerosis as a cause of permanent grounding and the effect of stapedectomy are considered. Chronic otitis media and the indications for grounding compared with those permitting continued flying are examined. The relative and absolute indications for grounding in cases of chronic otitic barotrauma are discussed. Perceptive deafness and labyrinthine causes of vertigo and their influence on fitness to fly are also described.

Author

**N72-14107\*** Institute of Aviation Medicine, Fliegerhorst (West Germany)

#### CAUSES FOR PERMANENT GROUNDING AND REJECTION IN THE ENT DEPARTMENT OF THE INSTITUTE OF AVIATION MEDICINE OF THE GERMAN AIR FORCE

G. Froehlich. In AGARD Clinical Causes for Grounding. Nov. 1971. 3 p. (See N72-14090-05-05)

Avail. NTIS

From 1959 to 1968 there were 22,800 periodic reexaminations of pilots and student pilots of the German armed forces. 55 or 0.24% of these were permanently grounded. In this group, 38 were students with marked high tone hearing losses due to impact noise at the shooting range. The remainder suffered from recurrent barotitis (3), vestibular disease (3), chronic sinusitis (2), allergic rhinitis (1), and Meniere's disease (1). The rates for permanent rejections of applicants for flight training decreased considerably after the adoption of more flexible hearing standards in 1966. Again most of the rejections were due to considerable hearing losses caused by impact noise. In a sample of 2000 initial examinations, the rejection rates were highest among young Army officers and Army NCOs and lowest among Air Force applicants. The main causes for temporary grounding of applicants were sinusitis, marked septal deviations, catarrhal otitis media, and chronic tonsillitis. All these cases were accepted for flying training if there was full recovery after proper treatment. Cases with simple mastoidectomy and small atrophic scars of the tympanic membrane are acceptable as well as cases with tympanoplasty type 1, provided the ears are functionally normal.

Author

**N72-14108\*** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

#### OPHTHALMOLOGICAL CAUSES FOR GROUNDING: A 10 YEARS REPORT

Dietrich Kuehnle. In AGARD Clinical Causes for Grounding. Nov. 1971. 4 p. (See N72-14090-05-05)

Avail. NTIS

From 1959 to 1969, 51 pilots in the German Air Force

were permanently grounded on the basis of ophthalmological diagnoses. The total number of examinations made was 24 396. These 51 cases were classified according to diagnosis. They were as follows: anomalies of refraction (28); anomalies of color sense (3); anomalies of accommodation (1); anomalies of stereopsis (1); blepharitis (1); anomalies of pupillary function (1); cataract (2); aphakia (2); retinal diseases, including 2 retinal detachments (7); and glaucoma (5). Author

**N72-14109#** Canadian Armed Forces Inst. of Environmental Medicine, Toronto (Ontario)

**DIABETES MELLITUS IN FLYING PERSONNEL**

W. J. C. Stevenson. In AGARD Clinical Causes for Grounding. Nov. 1971. 6 p. refs. (See N72-14090 05 05). Avail. NTIS

The Central Aircrew Medical Board at the Canadian Forces Institute of Environmental Medicine assessed fifteen aircrew members in the past ten years who were referred because of abnormal glucose tolerance observed following incidental findings of reducing substances in the urine at time of routine urinalysis. The clinical findings, investigation procedures, and followup are discussed for two of the fifteen cases. These were referred because evidence suggested possible adult onset of diabetes mellitus. Four of the fifteen were permanently grounded; the remainder were returned to flight duties. One individual case was followed for ten years without development of the overt disease or any associated symptomatology. Reference is made to Canadian Air Force policy in dealing with cases of diabetes mellitus in aircrew members. Author

**N72-14110#** Royal Air Force, Farnborough (England)

**PSYCHIATRIC CASUALTIES AMONG AIRCREW OF THE ROYAL AIR FORCE OF GREAT BRITAIN FOR TEN YEARS 1959 TO 1968**

P. J. O'Connor. In AGARD Clinical Causes for Grounding. Nov. 1971. 4 p. (See N72-14090 05 05). Avail. NTIS

The causes of 262 permanent groundings for psychiatric illness in the Royal Air Force are discussed in detail for the ten years 1959 to 1968. One quarter of the cases were grounded for psychotic illness and three quarters for neuroses and personality disorders. Psychiatric wastage accounts for 10% of the total medical wastage. Author

**N72-14111#** Institute of Aviation Medicine, Fliegerhorst (West Germany)

**PSYCHOLOGICAL CAUSES FOR GROUNDING WITH SPECIAL CONSIDERATION OF PSYCHOSOMATIC SYNDROMES AND FEAR OF FLYING**

K. Gerbert and H. P. Goerres. In AGARD Clinical Causes for Grounding. Nov. 1971. 7 p. refs. (See N72-14090 05 05). Avail. NTIS

One third of all groundings of pilots in the German Air Force within the last ten years was due to psychological reasons. This number is surprisingly high, considering the fact that the aviation psychologists do not routinely see every pilot. It is the task of the psychologists to select potential washouts and to investigate the causes of psychophysical performance decrements. Anxiety and fear are analyzed as flying stress reactions. Author

**N72-14112#** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

**FLIGHT GROUNDING FOR PSYCHOLOGICAL AND PSYCHIATRIC REASONS [LES INTERDICTIONS DE VOL POUR RAISONS PSYCHOLOGIQUES ET PSYCHIATRIQUES]**

Rene Gelly. In AGARD Clinical Causes for Grounding. Nov. 1971. 6 p. In FRENCH (See N72-14090 05 05). Avail. NTIS

Two sorts of psychopathology exist among aviators. The first is general, independent of the subject's professional life, and is associated with other aspects of his life. The second is a

specific psychopathology which is due to the difficulties of acclimatic adaptation and which occurs almost uniquely in the domain of the subject's professional life. Observations made for French Air Force personnel in 1969 were collected and divided into classes in order to study the distinction implied in diagnosis, prediction, treatment, and deciding flight aptitude in psychological cases. The classes considered were the general psychiatry of flying personnel and their specific psychopathology. Information on diagnostics, aptitude decisions, and development over a year of observation was also collected. Therapy and medical administrative suggestions are presented for the two pathologies. Transl. by K. P. D.

**N72-19119#** Advisory Group for Aerospace Research and Development, Paris (France)

**LINEAR ACCELERATION OF IMPACT TYPE**

26 Feb. 1971. 436 p. refs. In ENGLISH and FRENCH. Presented at the Aerospace Med. Panel Specialist Meeting, Oporto, Portugal, 23-26 Jun. 1971.

(AGARD CP-88-71). Avail. NTIS. HC \$6.00; MF \$0.95.

Recent aviation and automobile accidents are reviewed in an effort to reduce the human injury. The biodynamics, physiology, pathology, and clinical aspects of linear acceleration impact are discussed. For individual titles, see N72-19120 through N72-19163.

**N72-19120#** Royal Air Force, Farnborough (England)

**TECHNICAL EVALUATION OF THE AEROSPACE MEDICAL PANEL SPECIALISTS MEETING ON LINEAR ACCELERATION (IMPACT TYPE)**

D. H. Glaister. In AGARD Linear Acceleration or Impact Type. 26 Jun. 1971. 4 p. (See N72-19119 10-05). Avail. NTIS. HC \$6.00; MF \$0.95.

Crash injury research is discussed, including biodynamics of impact, injury mechanisms and pathology, and techniques for impact attenuation. Impact forces related to seat ejection, facilities for impact studies, impact protection (restraint system), and head protection devices are considered. Recommendations for additional research are presented for crashworthiness, standardization, head and neck protection, ejection injury to the spine, and soft tissue injury mechanisms. J. A. M.

**N72-19121#** Army Aeromedical Research Lab., Fort Rucker, Ala.

**SYMPOSIUM ON LINEAR ACCELERATION OF IMPACT TYPE INTRODUCTORY REMARKS**

Edward J. Baldes. In AGARD Linear Acceleration or Impact Type. 26 Jun. 1971. 5 p. refs. (See N72-19119 10-05). Avail. NTIS. HC \$6.00; MF \$0.95.

Biodynamic and bioengineering applications to operational problems in the interface of man-machine relationships are reviewed. Safety principles are discussed for reducing injuries. Data are presented on accidents in aircraft training programs and on highways. Author

**N72-19122#** Laboratoire UTAC, Montlhéry (France)

**ECONOMIC PROCEDURES FOR SIMULATING THE EFFECTS OF LINEAR COLLISIONS IN VIEW OF STUDIES OF RESTRAINING DEVICES FOR THE PROTECTION OF AUTOMOBILE OCCUPANTS [PROCEDES ECONOMIQUES POUR SIMULER LES EFFETS DE COLLISIONS LINEAIRES EN VUE DE L'ETUDE DES DISPOSITIFS DE RETENUE OU DE LA PROTECTION DE OCCUPANTS D'UN VEHICULE AUTOMOBILE]**

E. Chapoux and H. LaGuén. In AGARD Linear Acceleration or Impact Type. 26 Jun. 1971. 16 p. In FRENCH (See N72-19119 10-05).

Avail. NTIS. HC \$6.00; MF \$0.95.

An apparatus was designed and perfected for collision studies, which involves stopping of passenger movement. The equipment described is being used in many European laboratories and provides many advantages at a minimal cost price.

Transl. by K. P. D.

**N72-19123#** Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

**AIRCRAFT ACCIDENT INJURIES AND AIRCRAFT ACCIDENT RECONSTRUCTION**

S. Krefft. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 11 p. refs (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

The development and mechanics of injuries to aircraft passengers are examined. The reconstructive conclusions with respect to the sequence of events, that can be drawn from the type, appearance, location, extent, and severity of the external and internal injuries sustained by the crash victims are discussed. Investigations are used to illustrate that owing to the injuries suffered in an aircraft accident the crash victims can bear silent witness and not only provide important clues but solid evidence permitting a reconstruction of the sequence of events. Author

**N72-19124#** Royal Air Force Inst. of Pathology and Tropical Medicine, Aylesbury (England)

**HISTOPATHOLOGICAL RESPONSES TO DECELERATION**

J. K. Mason. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 6 p. refs (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

Personal observations of 340 fatal aircraft accidents are used to study simple confirmation of lacerations to victims. The physical changes are described with reference to quantitation and differential diagnosis from natural disease. The significance of pulmonary tissue embolism is emphasized. Author

**N72-19125#** Michigan Univ., Ann Arbor. Inst. of Science and Technology

**MAN'S SURVIVABILITY OF EXTREME FORCES IN FREE FALL IMPACT**

Richard G. Snyder. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 13 p. refs (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

Exposure to extreme forces greater than experimentally tolerable were studied through human accidental or suicidal free-falls. Examples selected from nearly 30,000 free-fall cases illustrate the range of injury and fatality limits found under various conditions. Terminal velocity free-falls 53-64 m/sec (120 mph) without benefit of parachute were survived by Soviet, French, United Kingdom, and U.S. pilots and paratroopers under emergency ejection or evacuation conditions. Biophysical, biomechanical, and biomedical variables are discussed. Results indicate that there is a complex balance between factors of magnitude, calculated rate of onset and event duration, body axis orientation, force distribution, and properties of the impacted surface. Author

**N72-19126#** Association Peugeot-Renault, la Garenne-Colombes (France). Lab. de Physiologie et de Biomechanique

**COMPARISON OF THE EFFECTIVENESS OF TWO PASSIVE RESTRAINT SYSTEMS [EFFICACITE COMPAREE DE DEUX SYSTEMES DE RETENUE PASSIVE]**

Claude Tarniere. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 13 p. refs. In FRENCH (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

Safety belts are discussed in regard to the optimization of webbing rigidity and the utilization of shock absorbers at chest level. Performance level is compared to that of inflatable bags. Completely passive, automatic belts are considered. Experimental data are presented in terms of improving global efficacy, various highway accident types, and the cost/efficiency ratio.

Transl. by K.P.D.

**N72-19127#** National Institutes of Health, Bethesda, Md. National Inst. of Neurological Diseases and Stroke

**PROTECTION OF THE BRAIN FROM INJURY DURING IMPACT: EXPERIMENTAL STUDIES IN THE BIOMECHANICS OF HEAD INJURY**

Ayub K. Ominaya and Arthur E. Hirsch (Natl. Highway Traffic Safety Admin.). In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 19 p. refs (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

Experimental data on head injury are summarized in three subhuman primate species undergoing controlled direct head impact and indirect impulsive head loading (whiplash). Testing of Holbourn's rotational hypothesis and the translation/cavitation hypothesis revealed discrepancies. Data are presented to show that a combination of heat rotation and skull distortion mechanisms are most injurious for brain damage during both direct and indirect impact. Current mathematical models with simultaneous experimental testing in development are reviewed. Author

**N72-19128#** Rochester Univ., N.Y. School of Medicine. BIODYNAMICS OF SPORTS INJURIES

John D. States. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 6 p. refs (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

Helmets and restraint systems used in automobile racing, modified football shoe cleats, and release ski bindings have reduced the injury risks in these sports. Knowledge of human injury tolerance was gained through the study of sports accidents, particularly the determination of injury mechanisms. Injury tolerance data determined in the laboratory was also useful in designing sports safety equipment. Author

**N72-19129#** Army Board for Aviation Accident Research, Fort Rucker, Ala.

**ANALYSIS OF US ARMY HELICOPTER ACCIDENTS TO DEFINE IMPACT INJURY PROBLEMS**

Joseph L. Haley, Jr. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 13 p. refs (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

An overall view of the occupant injury experience in U.S. Army helicopters from January 1967 through December 1969 is presented. These data show that 40 percent of all occupant fatalities occurred in survivable accidents. This percentage shows the need for further improvement of helicopter crashworthiness. The statistics further indicated that fire was the single largest fatality cause with head injuries next in rank. A group of severe but survivable helicopter accidents of the same time period was studied. The study included three types of Army helicopters. Study results indicated that the problem of postcrash fire fatalities was more severe in the utility and cargo helicopters. It was also shown that potentially hazardous displacement of the transmission and main rotor blades occurred in one of every three utility and cargo helicopter accidents studied. Further, a roll about the long axis usually occurred. At least one roll occurred in 2 of 3 light observation helicopter accidents, 5 of 8 utility helicopter accidents, and 1 of 2 cargo helicopter accidents. The tendency to roll highlights the need to consider sideward occupant restraint and transmission/rotor blade moorings in these helicopters. Author

**N72-19130#** Birmingham Univ. (England). Dept. of Transportation

**AN ASSESSMENT OF ACTIVE AND PASSIVE RESTRAINTS IN SERIOUS INJURY EUROPEAN CAR OCCUPANT COLLISIONS**

G. Murray Mackay. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 12 p. refs (See N72-19119 10-05)  
 Avail NTIS HC \$6.00/MF \$0.95

A field study of road accidents numbering 105 vehicles selected from the severe and fatal injury end of the injury spectrum are examined. The incidence of various crash configurations is outlined, together with the objects struck, and the rate with which the passenger compartment is penetrated. The relative frequencies of side impacts, and multiple and complex collisions are described. Each collision is examined in terms of the reduction in injuries to front seat occupants which might be obtained if an air bag was present in a similar manner each collision is examined to assess the benefit if a lap diagonal seat belt were worn. An overall judgement is therefore obtained.

on the relative benefits obtainable from airbags and belts. Belts are shown to be superior because they provide protection in a greater range of collision types. If a belt wear rate exceeding some 63% for drivers and 85% for front passengers were obtained then belts provide greater benefits than airbags. The importance of intrusion into the passenger compartment, especially in late collisions is emphasized as a restriction on restraint effectiveness in present day European car designs. Author

**N72-19131#** Naval Aerospace Medical Research Lab., New Orleans, La.  
**HUMAN DYNAMIC RESPONSE TO MINUS GX IMPACT ACCELERATION**

Channing L. Ewing and Daniel J. Thomas. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 12 p. refs (See N72-19119 10-05)

Avail. NTIS HC \$6.00/MF \$0.95

The purposes of the study were fourfold: (1) to measure precisely the complete input acceleration to the head and neck measured at the first thoracic vertebra; (2) to measure precisely the dynamic response of the head and neck to the input acceleration; (3) to develop a method of obtaining the data in such a form that automatic data processing may be used; and (4) to develop and validate a general method for the experimental measurement of the bioengineering characteristics of the human body with such precision, accuracy, and repeatability that a mathematical model of the human dynamic response to impact acceleration can be constructed. Author

**N72-19132#** Naval Aerospace Medical Research Lab., New Orleans, La.

**THEORETICAL MECHANICS FOR EXPRESSING IMPACT ACCELERATIVE RESPONSE OF HUMAN BEINGS**

Daniel J. Thomas and Channing L. Ewing. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 7 p. refs (See N72-19119 10-05)

Avail. NTIS HC \$6.00/MF \$0.95

The theoretical requirements for expressing the kinematics of human impact acceleration experimentation are presented. Two basic coordinate systems for expression of the kinematic information are identified as: (1) the body reference frame, defined in terms of the experimental subject's anatomy; (2) the laboratory reference frame. A general set of rules for deriving these coordinate systems is described. Variables and parameters are defined in terms of the general set of rules. The resulting descriptions are compared with definitions for use in prolonged acceleration. Author

**N72-19133#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Biodynamics and Bionics Div.

**BIODYNAMIC MODELS AND THEIR APPLICATIONS**

Hermann E. vonGierke. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 18 p. refs (See N72-19119 10-05)

Avail. NTIS HC \$8.00/MF \$0.95

Progress in modeling the mechanical response of man exposed to various environmental forces is discussed. Starting with a mathematical description of the mechanical and physical characteristics of the integument, soft and hard tissue, the numerous approaches taken and the results obtained from modeling various integrated elements such as the human vertebral column under vibration and impact loads, the chest and respiratory system under vibratory and blast loads and of the whole body system for selected force input conditions and locations are reviewed. To derive a capability of modeling specific injury modes or experimentally observed probabilities of injury curves for various parenchymatous and hollow organs as a function of the force input variables, more detailed and specialized models are being used such as, for example, the lumped parameter, discrete parameter, and continuum mode, of the spine or models considering nonlinear tissue behavior. The status and value of these models for studying the body's physical and physiological response, for understanding and predicting injury mechanisms and probability of injury, for scaling the results of

animal experiments, and for applying the models in protection engineering, such as escape and restraint systems design, are demonstrated. There is need for further experimental as well as theoretical work, in support of these practical biomedical and hardware requirements. Author

**N72-19134#** Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.

**THE BIODYNAMICS OF AIR BLAST**

Clayton S. White, Robert K. Jones, Edward G. Damon, E. Royce Fletcher, and Donald R. Richmond. In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 21 p. refs. Sponsored by NASA and AEC (See N72-19119 10-05)

Avail. NTIS HC \$8.00/MF \$0.95

After pointing out that accelerative and decelerative events are associated with the direct and indirect effects of exposure to blast-induced winds and pressure variations, some of the relevant biophysical parameters were selectively noted and discussed. These included the pressure-time relationship, species differences, ambient pressure effects, the significance of positional (orientational) and geometric (situational) factors as they influence the wave form, the pressure dose and the biologic response, and data bearing upon the etiology of blast injury. The consequences of pressure-induced violent implosion of the body wall and the significance of the associated variations in the internal gas and fluid pressures were described and emphasized, as were alternating phases of forced hemorrhage and arterial air embolization, fibrin thrombi, coagulation anomalies, and renal, cardiac and pulmonary sequelae. Tentative biomedical criteria consistent with recent interspecies scaling and modeling studies for assessing primary blast hazards were presented. Author

**N72-19135#** Department of Transportation, Washington, D.C. Natl. Highway Traffic Safety Administration

**LETHAL EFFECTS ON MAN OF UNDERWATER DETONATION OF A FIRECRACKER**

Arthur E. Hirsch and Ayub K. Ommaya (NIH). In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 5 p. refs (See N72-19119 10-05)

Avail. NTIS HC \$6.00/MF \$0.95

A firecracker exploded in contact with the skin within six inches of the skull base in a young man while he was swimming underwater. The resultant severe head injury and death appeared to be directly related to this underwater explosion. Reconstruction of the mechanics of this injury indicate that when the head is subjected to impact energies between 440 to 1800 in-lb and impact impulse between 1.8 to 3.5 lb-sec, both skull fracture and brain injury can occur. Author

**N72-19136#** Institutes fuer Wehrmedizin und Hygiene, Koblenz (West Germany)

**HUMAN STRESS LOADS INDUCED THROUGH SIMULATED PRESSURES ON UNDERGROUND SHELTERS**

G. Kleinhans and H. Dupuis (Technische Univ., Munich). In AGARD Linear Acceleration of Impact Type 26 Jun 1971. 9 p. refs (See N72-19119 10-05)

Avail. NTIS HC \$6.00/MF \$0.95

Within the constraints of a simulated nuclear strike, the human stress loads to be expected were assessed through physical measurements taken on dummies placed in an underground shelter. Results verified that under the given conditions, exposure to shock would not cause detrimental effects to the health or a reduction in efficiency, due to physical factors, of operators manning control desks in the underground shelter. It is pointed out that results obtained on dummies may be applied analogously to man only to a limited extent since no dummies showing human physiological and dynamic behavior were available. The assessment results apply only to the movement vectors observed during this test on shelter floor and walls. Conceivably other vector variations may produce fundamentally different results. The measuring data related to three different seating arrangements indicate technical possibilities for shock reduction. Author



N72-19137# Army Aeromedical Research Lab., Fort Rucker, Ala. Bioengineering and Evaluation Div

**PARACHUTING IMPACT INJURIES AT HIGH DROP ZONE ELEVATIONS ENVIRONMENTAL EFFECTS**

Stanley C. Knapp and George R. McCahan, Jr. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 9 p refs (See N72 19119 10 05)

Avail NTIS HC \$6 00 MF \$0 95

A review of parachuting injuries that are directly related to accelerative forces and impact is presented. The available and valid injury prediction statistics for a wide variety of parachuting activities is discussed. The environmental effects of wind shear, wind velocity, wind thermals, density altitude, terrain and topography, increased rates of descent, and temperature variations upon injury morbidity are analyzed. These effects were determined during experiments at 6,000 and 10,000 feet drop zone altitudes using the 32 feet parabolic apex vented-static line deployed parachute. Injury rates were four times greater than those expected or experienced at sea level elevations. The conclusions and recommendations will be of practical value in the training and refitting of parachutists for jumps into high elevation drop zones.

Author

N72-19138# Italian Air Force Aerospace Medical Center, Rome

**BEHAVIOUR OF SOME SERUM ENZYME ACTIVITIES IN MAN AFTER CRASH ACCIDENTS, CAUSING MASSIVE INJURIES**

G. Paolucci, G. Biundo, and A. Balla. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 5 p refs (See N72 19119 10 05)

Avail NTIS HC \$6 00 MF \$0 95

Observations were made of blood serum enzyme activities in an effort to verify the fact that such activity causes massive injuries and fractures to the human body. Several people involved in severe road accidents were observed for activities of the following enzymes: (1) Glutamic oxalacetic transaminase (GOT), (2) Glutamic pyruvic transaminase (GPT), (3) Lactate and Malate dehydrogenase (LDP-MHD), (4) Adolose (ALD), (5) Alkaline phosphates (ALKP), (6) Acid phosphate (AcP). Results show some enzyme activities increase in the most severely injured subjects and that a correlation exists between some enzyme activities and body damage. Results also indicate the possibility of evaluating the degree of body damage from certain enzyme activities and that some enzymes analyses, especially GOT, may be useful for diagnosis and medico-legal judgments.

Author

N72-19139# Aerospace Medical Research Labs Wright-Patterson AFB Ohio

**THE DYNAMIC BIOMECHANICAL NATURE OF SPINAL FRACTURES AND ARTICULAR FACET DERANGEMENT**

Leon E. Kazarian, Dale D. Boyd, and Henning F. vonGierke. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 25 p refs (See N72 19119 10 05)

(AMRL TR 71-17) Avail NTIS HC \$6 00 MF \$0 95

Through the application of appropriate scaling laws animal experiments, particularly on primates, are shown to be of value in explaining hard tissue injury mechanisms and individual organ injury potential in man exposed to impact forces. In support of this approach rhesus monkeys were anesthetized, radiographed, positioned in an impact carriage restrained by lap belt torso harness, and limb retention straps, and exposed to 1-Gz seated rectangular acceleration time histories from predetermined drop heights. Shortly following impact all primates were radiographed, killed, and a necropsy performed. Attempts were made by means of an injury classification system to determine injury potential as a function of plateau acceleration and pulse duration for the spinal column. Type, frequency, and severity of vertebral body centrum fractures along with injury to the vertebral appendages were classified. Vertebral articular facets apophyseal joints disorders and derangements proved difficult to identify radiographically due to poor X ray film resolution, overlying soft tissue, and bony margin shadows. Necropsy demonstrated a large percentage of primates exhibited this type of lesion. Injury

probabilities for the vertebral column established by radiographic and gross necropsy examination supplement and explain available knowledge on spinal injury mechanisms observed in the rhesus monkey.

Author

N72-19140# Strathclyde Univ., Glasgow (Scotland) Bioengineering Unit

**THE MECHANICAL AND STRUCTURAL CHARACTERISTICS OF CONNECTIVE TISSUE**

Bryan Finlay, John H. Evans, James F. North, Tom Gibson, and Robert M. Kenedi. In AGARD Linear Acceleration of Impact Type 26 Feb 1971 10 p refs (See N72 19119 10 05)

Avail NTIS HC \$6 00 MF \$0 95

A range of test procedures is described in detail and typical data are given for human skin to illustrate the rate sensitive non-linearities that may be encountered with these materials. Criteria used to assess the failure of a tissue are considered on the basis of impairment of physiological function. The normal structure of skin and its response to stress is illustrated by the use of the scanning electron microscope and the construction of a tendon model is described before finally assessing the whole process of tissue modelling.

Author

N72-19141# Hughes Tool Co., Culver City, Calif. Aircraft Div

**DESIGNING HELICOPTERS FOR IMPROVED CRASH SURVIVABILITY**

Henry G. Smith. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 14 p refs (See N72 19119 10 05)

Avail NTIS HC \$6 00 MF \$0 95

The fundamental theory for providing attenuation of the crash impact is reviewed, with emphasis upon understanding the relationship of the fundamental parameters of the problem. Based upon operating statistical data in regard to potentially survivable crashes, along with engineering studies of any new helicopter design, design objectives can be established for the level of crash protection to be provided for the occupants. In problems of this type, a tradeoff always exists between size and weight penalties incurred for crash survivability versus the value of that same amount of size or weight for performance, payload, armor, or armament. Methods of attenuating or absorbing the crash impact in a gradual manner are the key to the provision of high crash protection levels while imposing minimum weight penalty upon the helicopter. Operating experience confirms that improved helicopter crash survivability can actually be obtained in a military operational environment. In addition to the improvement of survivability, improved morale of the crew members was a side benefit. The current trends of crash protection for new helicopter designs are discussed with implications of further improvement from the crash survivability standpoint in future helicopters.

Author

N72-19142# Cornell Aeronautical Lab., Inc., Buffalo, N.Y.

**AUTOMOBILE STRUCTURAL CRASHWORTHINESS CONCEPTS FOR CRASH PROTECTION**

Patrick M. Miller. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 16 p refs (See N72 19119 10 05)

(Contract DOT-FH-11-6918)

Avail NTIS HC \$6 00 MF \$0 95

A series of full scale automobile crash tests were conducted to determine the structural crashworthiness performance of conventional automobiles and to evaluate the performance of structural concepts designed to provide protection during frontal and lateral impacts with fixed objects. Conditions believed to be representative of severe single vehicle accidents, where automobiles impact narrow obstacles, were developed and used in the study. The objectives of the structural modifications were to produce a more uniform energy absorption, i.e. more uniform decelerations near 40 g's and 20 g's respectively for frontal and lateral collisions. The frontal structural modifications considered both front and rear engine vehicle designs and were evaluated under impacts with a rigid pole barrier where the collision speeds ranged from 35 MPH to 63 MPH. These structural modifications were designed so that the entire distance in front of the passenger compartment could be used for energy

absorption. The results demonstrated that the modifications when coupled with this restraint system provide for a force limiting system on the occupant for this range of impact conditions. Author

**N72-19143#** Wright Co. Kettering, Ohio  
**ARMOR MATERIALS FOR LIFE SUPPORT**  
 Robert Fred Roisten, Joseph G. Dunleavy, and Edward G. Budine  
*In* AGARD Linear Acceleration of Impact Type 26 Jun 1971  
 14 p refs (See N72-19119 10-05)  
 Avail NTIS HC \$6 00/MF \$0 95

A historical review of armor personnel protective devices is presented together with the philosophy of the use/disuse of armor. The current levels of protection, armor designs and materials state-of-the-art are discussed. Author

**N72-19144#** Deputy Inspector General for Inspection and Safety (Air Force) Norton AFB, Calif.  
**OPERATIONAL ASPECTS OF FORCES ON MAN DURING EJECTION. EXTRACTION ESCAPE IN THE US AIR FORCE, 1 JANUARY 1968 - 31 DECEMBER 1970**  
 Robert H. Shannon. *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p (See N72-19119 10-05)  
 Avail NTIS HC \$6 00/MF \$0 95

A study of 468 ejections in the United States Air Force (USAF) reported during the period 1 January 1968 to December 1970 disclosed that one in nine crew members involved received major or fatal injuries as a result of forces encountered from system initiation to parachute opening. In 49 cases the injuries received were classified as major (nonfatal), and three crew members were fatally injured. The majority of the major injuries were attributed to the initial forces of ejection and were primarily compression fractures of the vertebral column. These injuries continue to occur with consistent frequency in spite of the fact that the maximum accelerations of the catapults in use today are well below human tolerances. The major factors which influence the incidence of ejection force injuries are the type catapult used, ejection posture, and age of the individual involved. Of the three, ejection posture appears to be the single most critical factor. The correlation of the individual's weight by type catapult was not remarkable. The frequency of injuries attributed to G-forces showed a significant increase over previous studies of USAF ejection escape experience. Although the incidence of high speed ejections has increased only slightly, G-force injuries occurred in 4 percent of all nonfatal ejections and accounted for 12 percent of the total major injuries. Author

**N72-19145#** Loughborough Univ. of Technology (England)  
 Dept. Ergonomics and Cybernetics  
**MEASUREMENT OF HUMAN RESPONSES DURING IMPACT**

J. Sandover. *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 12 p refs (See N72-19119 10-05)  
 Avail NTIS HC \$6 00/MF \$0 95

In response to a need for information on the dynamic properties of man when using ejection seats, equipment has been developed to simulate the transient acceleration of ejection. The equipment, and the data acquisition and processing systems, are described. The apparatus was used for mechanical impedance studies and performs adequately up to 30 Hz. The present experimental program is designed to provide information on the variations of mechanical response of individual subjects and between subjects in a relatively restrictive experiment (e.g. hard seat, upright posture, low acceleration levels). The experiments so far indicate the existence of a series resonance at 9 to 10 Hz. The use of mechanical impedance techniques leads to accurate measurement of mechanical response at the input to the body but does not offer a great deal of evidence for the postulation of detailed models. For this reason internal and external transmissibility measurements are advocated. Some preliminary transmissibility measurements are recorded. Considered of the literature and the transmissibility measurements indicates deficiencies in many models of the body, and the need for a simple direct approach. Author

**N72-19146#** Centre d'Essais en Vol, Bretigny-sur-Orge (France)  
 Lab de Medecine Aerospatiale  
**EJECTION ACCELERATION: PHYSIOLOGICAL EFFECTS, TOLERANCE [ACCELERATIONS A L'EJECTION: MOYENS D'ETUDE EFFETS PHYSIOLOGIQUES, TOLERANCE]**  
 R. Auffret, H. Seris, J. Demange, and R. P. Delahaye. *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 6 p refs  
*In* FRENCH (See N72-19119 10-05)  
 Avail NTIS HC \$6 00/MF \$0 95

The physiological effects of acceleration and ejection on man are studied with the aid of a centrifuge. Major efforts were made to establish human tolerance to different acceleration stresses and determine the occurrence of lumbosacral spinal injuries, particularly intervertebral disks. The characteristics and performance of the centrifuge are included. Transl. by E.H.V.

**N72-19147#** Royal Aircraft Establishment, Farnborough (England) Human Engineering Div.  
**BLAST TESTING AIRCREW ESCAPE EQUIPMENT INCLUDING AN ACCOUNT OF A NEW TRANSONIC TEST FACILITY**

J. M. Rayne. *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs (See N72-19119 10-05)  
 Avail NTIS HC \$6 00/MF \$0 95

The design of a facility and its performance in determining the effectiveness of aircrew equipment to air blasts up to Mach 1.3 are discussed. In this device the air speed decay profile is programmed and can be made to simulate a range of post ejection conditions from sea level to altitude. Tests on a protective helmet demonstrate that it will probably be practicable to give head protection up to about 700 kt at sea level. However, failures of the visor which have occurred, show that explosive disintegration of the whole helmet follows at air speeds from 600 kt upwards. Helmet and visor failures usually occur within 100 msec of exposure and the blast effect can be regarded as an impact. In testing helmets therefore, the total duration of exposure to severe blast does not appear to be important. On the other hand, fabric is destroyed by the effects of flutter and the extent of damage seems to be time dependent. Therefore, in testing fabric protective equipment the shape of the air flow decay curve may well be important. Author

**N72-19148#** Centre d'Essais en Vol, Bretigny-sur-Orge (France)  
**RADIOLOGICAL STUDY OF SPINAL INJURIES TO PILOTS UNDERGOING SUDDEN EJECTION [ETUDE RADIOLOGIQUE DES LESIONS DU RACHIS CHEZ LES PILOTES AYANT SUBI UNE EJECTION]**  
 R. P. Delahaye, H. Seris, R. Auffret, G. Gueffier, and P. J. Metges. *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs  
*In* FRENCH (See N72-19119 10-05)  
 Avail NTIS HC \$6 00/MF \$0 95

Spinal injuries to pilots caused by sudden ejection are studied radiologically. The study was made in an attempt to determine the exact traumatic injury, the vertebrae involved, the localization, and the type of fractures. The fractures caused by the propulsion of the ejection seat are also studied. It was determined that the ejection seat usually caused injuries to the 6th, 7th and 8th vertebrae; it was also determined that the position of the pilot upon ejection contributes to spinal injuries. Transl. by E.H.V.

**N72-19149#** Hellenic Air Force General Hospital, Athens (Greece) Orthopaedic Dept.  
**SOME OBSERVATIONS ON COMPRESSION FRACTURES OF THE SPINE IN EJECTED GREEK PILOTS**  
 Pan. P. Symeonides. *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 3 p refs (See N72-19119 10-05)  
 Avail NTIS HC \$6 00/MF \$0 95

The causes of compression fractures in Greek pilots during the decade 1960-1969 were investigated. Resumption of duties by pilots with such fractures was studied. It was found that 18 percent of the ejected pilots sustained compression fractures of the spine. All fractures occurred during ejection and were located at the dorsolumbar region of the spine (T10 to L3). There was

sufficient evidence that excessive tightening of the ejection seat belts (shoulder/buttocks) produces a permanent flexion of the spine which thus becomes more vulnerable during ejection. If the wedging of a vertebra following a fracture does not exceed 1/3 of the height of the vertebral body and the symptoms are mild enough, the pilot may return to the active service as jet pilot. If wedging is greater than 1/3, he should not resume his previous duties either as jet or helicopter pilot because the created local kyphosis of the spine renders the neighboring vertebrae more vulnerable. Author

**N72-19150#** Civil Aeromedical Inst., Oklahoma City, Okla. Protection and Survival Lab

#### DESIGN CONSIDERATIONS FOR IMPACT TEST FACILITIES

Richard F. Chandler. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 10 p refs (See N72-19119 10-05)  
Avail NTIS HC \$6.00/MF \$0.95

With the advent of World War 2 pilot shortage necessitated scientific investigation of the causes of crash injury. These early investigations made use of a variety of test facilities, including swing seats, acceleration towers, drop towers, acceleration tracks, and deceleration tracks. The facilities served as a basis for similar devices in use today. The purpose of these facilities is to produce a controlled impact representative of an actual crash. Good simulation of the magnitude of acceleration changes is possible on these facilities, but none provide exact replication of the change in acceleration direction which is experienced in a crash. Author

**N72-19151#** Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

#### A LINEAR DECELERATION TRACK

A. F. Giles. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 9 p (See N72-19119 10-05)  
Avail NTIS HC \$6.00/MF \$0.95

The linear decelerator is housed in a building 52 m (170 ft) long and has a track length of 45 m (150 ft). The 545 kg (1200 lb) test vehicle is capable of carrying a payload of 160 kg (350 lb) and is propelled by rubber bungee ropes. It can attain a peak velocity of 23 metres/second (75 ft/sec). The arrester mechanism is capable of producing a peak vehicle deceleration of up to 50g and consists of a steel cable harness stretched across the track, each end being connected to the piston of a hydraulic cylinder. When the vehicle displaces the cables, movement of the pistons squeezes hydraulic fluid from each cylinder through a metered orifice, resulting in a controlled deceleration force on the vehicle. The profile shapes available are a half sine wave, a sine wave with a 50 millisecond plateau, a double peak, or a triple peak. Gravity onset rates can be varied from 60g/second to 750g/second. Author

**N72-19162#** Max-Planck-Institut fuer Arbeitsphysiologie, Dortmund (West Germany)

#### AN ELECTRO-HYDRAULIC SYSTEM FOR SIMULATIONS OF COLLISIONS

W. Lange. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 4 p (See N72-19119 10-05)  
Avail NTIS HC \$6.00/MF \$0.95

Equipment is described which is used in simulations of automobile collisions. The device consists mainly of a guided sled on which the cabin can be mounted forward, obliquely, laterally, or backward. The sled, which can be accelerated between 0 and 30 g, is piston powered and controlled by an electrohydraulic catapult. Mechanical, hydraulic and electrical design features as well as the recording system are described. Author

**N72-19153#** Fiat SpA, Turin (Italy)  
FIAT CATAPULTS

E. Franchini. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs (See N72-19119 10-05)  
Avail NTIS HC \$6.00/MF \$0.95

An outline is drawn of several propulsion systems adopted

to launch a car against an obstacle and the reasons are given why the catapult system was preferred. This system allows the possibility of launching a car indoors, it is simple and of low cost and has a high operational flexibility. A description is given of the low and medium speed impact catapult and of the new catapult for collisions at up to 80 km/h of cars up to 2000 weight. The catapult design diagrams are given. The control and operation devices and the measuring instrumentation, are described. The different types of test run with the catapult are illustrated. They include: (1) head-on collision against barrier at 90 degrees or at other angles of approach; (2) side impact against stationary car; (3) rear end collision; (4) wedging under stationary truck front, side or tail; (5) launching of car, raised clear of ground and placed transversally on the trolley to simulate the side skidding impact against barrier or pole; (6) sudden braking of a complete car to study the behavior of dummies in their impact against passenger compartment interior; (7) sudden braking of a dolly, on which a dummy is installed to study seat belts (or other restraint) or the impact of driver against steering wheel. Author

**N72-19154#** Motor Industry Research Association, Undley (England)

#### THE MIRA VEHICLE IMPACT TEST FACILITY

T. R. Aston. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p (See N72-19119 10-05)  
Avail NTIS HC \$6.00/MF \$0.95

Tests were conducted out of doors initially, but with the introduction of legislation a large number of certification and compliance tests became necessary and, mainly because of the unpredictable climate in the U.K., it was found necessary to build an indoor test rig. On this test rig a linear induction motor is used as the prime mover and it is capable of accelerating vehicles of up to 10,000 lb in weight to any speed up to 30 mph. Special provision was made for high speed cine photography and electronic instrumentation, and the entire test rig is automatically controlled. In order to safeguard personnel a comprehensive safety interlock system was incorporated. Author

**N72-19155#** National Bureau of Standards, Washington, D.C.  
THE MATHEMATICS OF IMPACT, AND CRASH TESTS OF AIRPLANE AIRBAG RESTRAINT SYSTEMS

Carl C. Clark. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs (See N72-19119 10-05)  
Avail NTIS HC \$6.00/MF \$0.95

The  $r$  sub  $x$ ,  $g$  sub  $y$ , and  $g$  sub  $z$  linear acceleration and  $r$  dot sub  $x$ ,  $r$  dot sub  $y$ , and  $r$  dot sub  $z$  angular acceleration terminology (the latter representing radians/sec sq) is reviewed. It is urged that the representation of human acceleration environments by accelerometers be filtered to be flat (with less than 0.5 db variation) in response from 0 to 240 Hertz and then attenuated above 240 Hz at 12 db per octave, in preference to the more common representation by ac accelerometers (flat from about 10 to 2000 Hertz). This latter representation often obscures biologically important accelerations in metal ringing spikes. Illustrations are drawn from crash studies of airplane airbag restraint systems and from mathematical representations of passenger compartment loads for automobile crashes of various types. Author

**N72-19166#** Michigan Univ., Ann Arbor

#### BIOMECHANICS OF RESTRAINT AND IMPACT ATTENUATION SYSTEMS

Verne L. Roberts and James H. McElhaney. In AGARD Linear Acceleration of Impact Type 26 Jun 1971 9 p refs (See N72-19119 10-05)  
Avail NTIS HC \$6.00/MF \$0.95

The methodology and results from research program concerning the protective aspects of passive restraint systems are provided. The criteria which should be used in the evaluation of passive restraints are provided and the experimental and analytical tools to define restraint performance are discussed. Research indicates that passive restraints can provide protection equal to that provided by belt systems and that a passive

restraint must be carefully integrated with the vehicle interior to provide optimum protection. Author

**N72-19157#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio

**RESTRAINT DESIGN. LABORATORY TEST AND EVALUATION OF OPERATIONAL EFFECTIVENESS**

James W. Brinkley and John T. Shaffer. In AGARD Linear Acceleration of Impact Type. 26 Jun 1971. 7 p. refs. (See N72-19119 10-05)

Avail NTIS HC \$6.00/MF \$0.95

Methods used to design contemporary personal flight equipment, such as restraint systems and ejection seat cushions, are presented. Emphasis is placed on the acceleration protection aspects of the design. Both analytical modeling and experimental determination of material characteristics are discussed. Experimental results of laboratory impact test evaluations of three items of personal equipment using human subjects are presented. These experiments include an evaluation of three operational restraint harnesses at  $g$  sub  $x$  acceleration levels up to 15  $g$ , a study of the acceleration transmission characteristics of ejection seat cushions, and work completed in the study of acceleration protection provided by rapidly deployed air bag restraint systems. The implications of the experimental findings are discussed and related to operational experience. Author

**N72-19158#** Royal Air Force Inst of Aviation Medicine, Farnborough (England)

**A CASE FOR THE NEGATIVE-G STRAP**

R. C. Reade. In AGARD Linear Acceleration of Impact Type refs. (See N72-19119 10-05)

Avail NTIS HC \$6.00/MF \$0.95

The addition of a negative- $g$  strap is proposed in order to overcome some of the inadequacies of current restraint harnesses. The effects of aerobatics, vertical vibration, and crash impact on a harness are detailed, and the way in which the negative- $g$  strap improves restraint is described. The advantages and disadvantages of negative- $g$  straps in harnesses are discussed, and details of construction, location, and fitting are presented. Author

**N72-19159#** Max-Planck-Institut fuer Arbeitsphysiologie, Dortmund (West Germany)

**SEVERE FRONTAL COLLISIONS AND RESULTING INJURIES WITH AND WITHOUT RESTRAINING DEVICES**

W. Lange. In AGARD Linear Acceleration of Impact Type. 26 Jun 1971. 10 p. refs. (See N72-19119 10-05)

Avail NTIS HC \$6.00/MF \$0.95

The results of simulated frontal collisions are briefly described. Types and magnitudes of injuries sustained by cadavers depended on (1) whether or not they were restrained by safety belts, (2) type and stiffness of belts, (3) absence or presence of steering assembly and instrument panel, and (4) interactions between body, harness and structures in the driver's space. Two pilot studies with air bags yielded conflicting results. Author

**N72-19160#** Royal Air Force Inst of Aviation Medicine, Farnborough (England)

**PROTECTION OF THE HEAD**

J. A. Gilves. In AGARD Linear Acceleration of Impact Type. 26 Jun 1971. 3 p. (See N72-19119 10-05)

Avail NTIS HC \$6.00/MF \$0.95

The protective helmets developed to ameliorate the effects of impact on the head improve survival and reduce injury in aircraft accidents. However, they would be aided by improvements in restraint systems and better work space design. Aircraft protective helmets should continue to be designed to deal with high energy rather than repetitive low energy blows. The multiple functions of helmets make it difficult to meet all requirements without excessive size and weight. Reduction in

both weight and size would be desirable, but current standards of protection should be maintained. The impact test method used in helmet development should take accident findings into account and should involve a small number of high energy blows. Author

**N72-19161#** Michigan Univ., Ann Arbor, Biomechanics Dept. THE BIOMECHANICAL ASPECTS OF CRASH HELMET DESIGN

James H. McElhaney, Verne L. Roberts, and Richard L. Stalnaker. In AGARD Linear Acceleration of Impact Type. 26 Jun 1971. 8 p. refs. (See N72-19119 10-05)

Avail NTIS HC \$6.00/MF \$0.95

A head injury model capable of predicting head injury through a maximum strain criteria was developed. This model is coupled to a helmet model and the combination allows the prediction of optimum helmet performance characteristics within a given set of constraints including size and weight. Several model exercises consisting of varying coupling parameters are presented. It was concluded that helmet performance is improved by decreasing elastic stiffness and increasing damping properties. Author

**N72-19162#** M. L. Aviation Co., Ltd., Maidenhead (England) THE DESIGN AND DEVELOPMENT TESTING OF AIRCREW PROTECTIVE HELMETS

J. Gregory. In AGARD Linear Acceleration of Impact Type. 25 Jun 1971. 7 p. (See N72-19119 10-05)

Avail NTIS HC \$6.00/MF \$0.95

Problems of design resolution are discussed for effecting a compromise between conflicting requirements for flight helmets. There is the need to protect flight crew members from all possible consequences of a hostile environment while allowing him to carry out his primary purpose of flying or operating the aircraft efficiently without hindrance from equipment. Stages of helmet design and component assembly testing are shown in sequences to indicate development from initial shape size conception and testing of individual components to full evaluation and testing of complete prototypes. Reference is made to the design development and testing of a general purpose military aircrew protective helmet mask assembly nearing completion in the U.K. Particular attention was paid to keeping the all up weight of the assembly under 1800  $g$  and in addition to conventional helmet facilities, incorporating an automatically lowering visor for a blast protection. Author

**N72-19163#** Snell Memorial Foundation, Sacramento, Calif. EVALUATION AND TESTING OF PROTECTIVE HEADGEAR

George G. Snively. In AGARD Linear Acceleration of Impact Type. 26 Jun 1971. 7 p. (See N72-19119 10-05)

(Grant EC-00013)

Avail NTIS HC \$6.00/MF \$0.95

Review is made of factors which must be considered in evaluating the performance of protective headgear. Standards of performance are considered and an analysis is presented of techniques utilized in helmet testing. Special attention is given to tests for penetration resistance, retention harness strength, and protection against impact. Author

**N73-19143#** Advisory Group for Aerospace Research and Development, Paris (France)

**PERFORMANCE AND BIODYNAMIC STRESS. INFLUENCE OF INTERACTING STRESSES ON PERFORMANCE**

Nov 1972. 110 p. refs. Proc. of AGARD Aerospace Med Panel Specialist Meeting Brussels, Jun 1972

(AGARD-CP 101) Avail NTIS HC \$7.50

The interactions of operational flight stresses and their effects on human performance are considered at this conference. For individual titles see N73-19144 through N73-19156

**N73-19144** Royal Aircraft Establishment, Farnborough (England) Environmental Effects Section

**EARLY THOUGHTS ON COMPOUND STRAINS**

Geoff Allen. *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 8 p. refs (For availability see N73-19143 10-05)

Jargon on the subject is briefly discussed, and it is reasoned that the term compound strains may frequently be more appropriate than combined stresses. Two compound strain problems of immediate and widespread importance, on which there is an urgent need to increase the present scanty information, are cited. The first is the effects of other mental and physical stresses on the signal to noise ratios required for communication; the second, the biodynamics of vibratory motion sickness, particularly the interaction with other loads such as vision, heat and odors. Author

N73-19146 Royal Aircraft Establishment, Farnborough (England) Human Engineering Div

**A FLIGHT TEST PROGRAMME TO STUDY THE EFFECTS OF ENVIRONMENTAL STRESSES ON AIRCREW OPERATING MILITARY STRIKE AIRCRAFT**

M. G. Trumper. *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 5 p. refs (For availability see N73-19143 10-05)

A flight test program is designed to obtain objective measurements of noise, vibration and temperature throughout typical profiles flown by military strike aircraft, and, as far as is possible, to correlate the measurements with aircrew reaction and performance. As a secondary object the program will investigate the usefulness of a water cooled suit installation as a means of relieving aircrew thermal stress in strike aircraft. Author

N73-19146 Aerospace Medical Research Labs, Wright Patterson AFB, Ohio

**TWO EXPERIMENTS ON THE EFFECTS OF COMBINED HEAT, NOISE AND VIBRATION STRESS**

Walter F. Grether. *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 8 p. refs (For availability see N73-19143 10-05) (AMRL TR 71-113)

Operational flying often exposes crew members to combinations of environmental stresses. To obtain a better understanding of such combined stress effects a major experiment was conducted using heat, noise and vibration, both singly and in combination. Measurements were made of tracking ability, choice reaction time, voice communication, mental arithmetic, visual acuity, body temperature, heart rate, weight loss and subjective ratings of the stress. In each of these measures, the combined triple stress produced greater effects than did the most severe single stress. Of the physiological measures, only heat stress produced significant effects, and the addition of noise and vibration produced no further effects. On the performance measures, particularly the tracking test, impairment was slightly less for the triple stress condition than for vibration only. Thus there were no additive interactions, and in fact some evidence of antagonistic interactions. Author

N73-19147 Aerospace Medical Research Labs, Wright Patterson AFB, Ohio

**COMBINED EFFECTS OF NOISE AND VIBRATION ON COGNITIVE AND PSYCHOMOTOR PERFORMANCE**

Henry C. Sommer and C. Stanley Harris. *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 10 p. refs (For availability see N73-19143 10-05) (AMRL TR 71-115)

Five studies on the combined effects of noise and vibration on psychomotor and cognitive performance are reported. Tracking and reaction time tasks were used as measures of psychomotor performance and a short term memory subtraction task was used as a measure of cognitive performance. The first study, using tracking performance, suggested a additive effect of noise and vibration on performance; however, this was not confirmed in a second study. Two additional studies conducted with the cognitive task indicated that detrimental effects on this task occurred only when noise and vibration were combined. Further, the effect seemed to be related to frequency of vibration, only 5 Hz

0.25 g<sub>rms</sub> vibration combined with noise produced an adverse effect on the task. The final investigation was concerned with the effect combined noise and vibration stress had on cognitive performance as a function of time of day. The results indicate that time of day does not appear to be a particularly strong variable. Author

N73-19148 Institute of Aviation Medicine, Fliegerhorst (West Germany)

**SOME CRITICAL COMMENTS ON THE MEASUREMENT OF IN-FLIGHT STRAINS**

W. Hoffelt and K. Gerbert. *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 4 p. refs (For availability see N73-19143 10-05)

Ways and means for aviation physicians and aviation psychologists to clarify the question of the overall stress imposed on flying personnel are discussed. Methodical difficulties are presented which result especially in the measurement of psychophysiological reactions to flying stress. Research psychological questionnaires and evaluation techniques are the only means which offer partial assessment possibilities concerning the problem of flying stress. Author

N73-19149 Royal Air Force Inst of Aviation Medicine, Farnborough (England)

**EMOTIONAL AND CARDIOVASCULAR STRESSES OF CENTRIFUGATION: EFFECT OF BETA RECEPTOR BLOCKADE ON HEART RATE RESPONSE**

D. H. Glaister, M. F. Allnutt, M. H. Harrison and P. Fennessy. *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 13 p. refs (For availability see N73-19143 10-05)

Twenty four subjects were used in a double blind trial to investigate the effect of beta adrenergic blockade on the heart rate response to acceleration. Oxprenolol (0.2 mg/kg body weight) or saline placebo was injected in paired trials and subjects then performed a tracking task and submitted to three centrifuge runs. Heart rate and blood pressure were monitored continuously. Oxprenolol reduced resting heart rate, and abolished a steady increase in base line heart rate seen in placebo experiments, and attributed to activation of the adrenal medulla. Tachycardia in response to +2G sub 7 acceleration was prevented by beta blockade, except in a group of six subjects experiencing their first ever centrifuge ride. Heart rates at +3G sub 7 were lowered by oxprenolol, the persistent tachycardia being attributed to a baroreceptor reflex mediated through a reduction in vagal tone. Pulse pressure was reduced by oxprenolol, especially during +3G sub 7 acceleration, an effect attributed to a reduction in cardiac output secondary to a fall in heart rate. G-logout tolerance was unaffected by beta blockade, but a small and unexplained decrement in tracking performance was observed. Author

N73-19160 School of Aerospace Medicine, Brooks AFB, Tex

**ESTIMATES OF PHYSIOLOGIC RESERVE AFTER ACCELERATION EXPOSURE IN MAN**

Frank R. Lecoco, Richard L. Lipman and Sidney D. LeVarett Jr. *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 6 p. refs (For availability see N73-19143 10-05)

A metabolic stressor was employed to provoke glucoregulatory hormone response immediately after exposure of subjects to acceleration stress. 2-deoxy-D-glucose, a glucose analog which produces severe intracellular hypoglycemia, was infused in eight normal male volunteers during a control period, immediately after an initial experience with acceleration, and after their fourth exposure to acceleration. Blood glucose, free fatty acids, insulin, growth hormone and cortisol and urinary epinephrine and norepinephrine were measured before and after each infusion of 2-deoxy-D-glucose. Although acceleration stress was modest, readily discernible changes in glucoregulatory response to the metabolic stressor were detected after exposure to acceleration. Author

**N73-19151 School of Aerospace Medicine, Brooks AFB, Tex.  
FINDINGS ON THE COST OF FLYING TRANSPORT  
MISSIONS**

Bryce O. Hartman and Henry B. Hale. In AGARD Performance and Biodyn. Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 7 p. refs. (For availability see N73-19143 10-05)

Physiologic and psychologic data from airlift missions flying in an operational configuration included inflight measurements during experimental double-crew missions and basic crew missions with staging for crew rest, as well as following approximately 125 basic missions using a special workload log. Psychologic analyses have evaluated subjective fatigue, sleep, and crew workload and the relationship between these and endocrine-metabolic activity assayed via urine. The cost of flying a transport mission in the face of multiple stresses characteristic of the operational environment is considered. Author

**N73-19152 Centre d'Essais en Vol, Breigny-sur-Orge (France)  
PHYSIOLOGICAL MODIFICATIONS DURING OPERA-  
TIONAL FLIGHTS OF LONG DURATION [MODIFICATIONS  
PHYSIOLOGIQUES AU COURS DE VOLS OPERATIONNELS  
DE LONGUE DUREE]**

R. Auffret. In AGARD Performance and Biodyn. Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 12 p. refs. In FRENCH (For availability see N73-19143 10-05)

Physiological changes occurring in pilots and navigators during long duration flights are examined as a function of energy fatigue. Data cover cardiac frequency, elimination of hydrocortisosteroides in urine, elimination of mucoprotein, and glycemia levels over a 24 hour period. Transl. by E.H.W.

**N73-19153 Naval Aerospace Medical Research Lab., Pensacola, Fla.  
Human Factors Engineering Research Div.  
EFFECTS OF PART-WHOLE TRAINING PROCEDURES  
UPON THE ACQUISITION OF COMPLEX SKILLS TO BE  
PERFORMED UNDER STRESS**

Richard S. Gibson. In AGARD Performance and Biodyn. Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 4 p. refs. (For availability see N73-19143 10-05)

Aviation training generally follows a sequential part task approach. The question of how many tasks should be presented at one time is considered. Seventy-two naval officer candidates participated in the experiment. Each subject experienced one of three training conditions prior to being exposed to the final test condition. The results provide insight into the use of part-whole training procedures for the acquisition of complex perceptual-psychomotor skills. Author

**N73-19154 Aerospace Medical Research Labs., Wright-Patterson  
AFB, Ohio**

**PERFORMANCE MEASUREMENT USING PILOT CON-  
TROLLED Gz MANEUVERING WITH SIMULATED OPERA-  
TIONAL TASK**

D. B. Rogers, F. M. Holden, C. R. Replogle, G. Potor, C. N. Day, R. E. VanPatten, K. A. Smiles, and G. C. Mohr. In AGARD Performance and Biodyn. Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 5 p. refs. (For availability see N73-19143 10-05)

(AMRL TR 72-31)  
A technique for human performance measurement using a closed loop centrifuge has been validated. The simulation utilized the pitch and roll dynamics of a high performance aircraft. The measurement criteria were hits on target using a display generated heads up gunsight on a maneuvering target aircraft. An important consideration was relationship between man as a passive rider versus man as an active participant in the generation of the Gz stress. Two important demonstrations resulting from this study are: (1) there is a significant difference in the ability of subject pilots to perform in closed versus open loop configuration, and (2) it is feasible to provide a mission related human performance metric in a selective simulation in which the Gz forces are dynamically realistic. A predictive heads up gunsight display is utilized with target trajectories representative of aerial combat maneuvers. Author

**N73-19155 Institute of Aviation Medicine, Fuerstenfeldbruck  
(West Germany)**

**PHYSIOLOGICAL STUDIES OF FATIGUE IN ACTIVITIES  
REQUIRING MENTAL CONCENTRATION IN HOT CLIMATE.  
THE INFLUENCE OF POSITIONING AND SENSORIAL  
IRRITATION**

J. Meyer-Delius. In AGARD Performance and Biodyn. Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 8 p. refs. (For availability see N73-19143 10-05)

Activities of vigilance without additional influence of psychical stress or energetic upset are demonstrated in hot and temperate climate with noradrenergic reaction. Mental effort with slightly increased energetic metabolism required 20% more time in hot climate to complete tasks than was required by persons working under temperate conditions. In this case the pulse rate was rising continuously. Under identical conditions of climate and mental work, but with noise, the pulse rate was significantly higher than without sensory irritation. Excitation of the sensorial senses leads to an additional increase in the peripheral vascular constriction. Opposed to thermoregulation it can cause disorganization and thus fatigue. Author

**N73-19156 School of Aerospace Medicine, Brooks AFB, Tex.  
Biodynamics Branch**

**THE USE OF PHYSIOLOGICAL PROTECTIVE MANEUVERS  
IN HIGH ACCELERATION ENVIRONMENTS**

S. J. Shubrooks, Jr. and S. O. Leverett, Jr. In AGARD Performance and Biodyn. Stress - Influence of Interacting Stresses on Performance. Nov. 1972. 9 p. refs. (For availability see N73-19143 10-05)

The physiological effects of voluntary maneuvers used for protection against +G sub z acceleration were studied on the human centrifuge. During both 15 sec. and 45 sec. rapid onset +G sub z exposures, the increases in tolerance achieved with the Valsalva straining maneuver (forcefully exhaling against the completely closed glottis) were found to be equivalent to those achieved with the M-1 maneuver (forcefully exhaling against the partially closed glottis), either combined with use of an anti-G suit or without the suit during generalized muscular tensing. Directly measured head level arterial pressure responses correlated with these findings. The use of positive pressure breathing, at levels of 25-40 mm Hg, was also found to result in increases in tolerance, both with and without use of the anti-G suit, at least equal to those obtained with the M-1 maneuver with less accompanying discomfort and fatigue. Author

**N74-18787# Advisory Group for Aerospace Research and  
Development, Paris (France)**

**BEHAVIOURAL ASPECTS OF AIRCRAFT ACCIDENTS**

K. G. G. Corkindale, ed. (Inst. of Aviation Med.) Dec. 1973. 72 p. refs. Papers presented at AGARD Aerospace Med. Panel Specialists Meeting, Soesterberg, Netherlands, 7 Sep. 1973. (AGARD-CP-132) Avail. NTIS HC \$6.75

A conference was conducted to discuss the influence of human factors on aircraft accidents. The subjects discussed were: (1) human factors approach to aircraft accident analysis; (2) human factor in cyclic aircraft accident patterns; (3) the application of aircrew opinions on cockpit tasks and equipment to flight safety research; and (4) the psychologists' role in aircraft accident investigation. The primary purpose of the conference was to determine if research projects in human factors engineering could result in a reduction in the pilot error accident rate. For individual titles see N74-18798 through N74-18804.

**N74-18798 Institute of Aviation Medicine, Fuerstenfeldbruck  
(West Germany)**

**PILOT FACTOR IN AIRCRAFT ACCIDENTS OF THE  
GERMAN FEDERAL ARMED FORCES**

B. Falckenberg. In AGARD Behavioural Aspects of Aircraft Accidents. Dec. 1973. 7 p. refs. (For availability see N74-18797 10-05)

An analysis with reference to the most frequent types of pilot error was made of 154 aircraft accidents which occurred in the years between 1967-1970. Of special interest were differences between pilots of jet, propeller aircraft and helicopter.

ters. The flying experience of the pilot, his age and other so called time variable factors were also taken into consideration. In general errors predominantly occurred during low level flight and during the landing phase immediately before touch down. In jet aircraft accidents the majority of errors committed by the pilot is due to an extreme workload in handling his aircraft. In pilots of the other categories particularly on propeller driven aircraft those types of errors are more pronounced which may be attributed to the pilot's flying attitude (in extreme cases resulting in violations). The findings of other authors relating to flying experience could be confirmed. As for the age distribution of pilots there were remarkable differences in comparison with the data in other publications. Author

**N74-18799** Naval Aerospace Medical Research Lab., Pensacola, Fla.

#### **HUMAN FACTORS APPROACH TO AIRCRAFT ACCIDENT ANALYSIS**

Richard H. Shannon and Wayne L. Waag. In AGARD Behavioural Aspects of Aircraft Accidents. Dec. 1973. 10 p. refs. (For availability see N74 18797 10 05)

Naval accident reports involving the P-3 and F-4 aircraft were examined over seven and five year periods, respectively. The critical incident technique was used to catalogue, describe and analyze operational flight crew errors in both aircraft. An in-depth study was performed in order to identify those problems which were common as well as specific to both aircraft. The P-3 and F-4 aircraft were selected because of their completely different fleet missions and handling characteristics. Human errors were categorized according to three types: (1) vigilance errors, (2) procedural errors, and (3) perceptual motor errors. Phases of flight operation were divided into four segments: (1) servicing, preflight, postflight, (2) start taxi, shutdown, (3) takeoff, landing, and (4) inflight. Four remedial areas were outlined for reducing human error: (1) crew coordination, (2) design, (3) discipline, and (4) training. From the F-4 accident reports 437 human errors were isolated while the P-3 reports contained 345 errors. Twenty-eight major error categories emerged from the analysis of these errors. The accident reports were further analyzed for the errors which both aircraft had in common. Twenty common error groups were found to occur in the P-3 and the F-4, representing 22.5% and 18.8% of the total errors, respectively. The flight segment of takeoff, landing, and the error type of procedures, shared the most commonality across the two aircraft. Author

**N74 18800** Defence and Civ. Inst. of Environmental Medicine, Downsview (Ontario).

#### **THE HUMAN FACTOR IN CYCLIC AIRCRAFT ACCIDENT PATTERNS**

Peter J. Dean. In AGARD Behavioural Aspects of Aircraft Accidents. Dec. 1973. 8 p. refs. (For availability see N74 18797 10 05)

An analysis of the human factors in aircraft accidents was conducted to isolate cyclic human factors which cause the accidents. The operational record of the CF-104 aircraft was used for the analysis. It was determined that the accidents tend to occur more frequently in January, April, July, and October than in the other months. The subjects discussed are: (1) the nature of the cyclic phenomena and how they influence man; (2) previous studies of cyclic patterns in aircraft accidents; and (3) specific cyclic factors related to aircraft accidents and recommendations for preventing aircraft accidents. Author

#### **N74 18801** Bunker Ramm Corp., Westlake Village, Calif. **EVALUATION OF THE ROLE OF THE SIMULATOR IN TRAINING AIRBORNE ASW OPERATIONS**

James E. Robins, Dorothy E. Finley, and Thomas G. Ryan. In AGARD Behavioural Aspects of Aircraft Accidents. Dec. 1973. 8 p. Sponsored by Naval Training Equipment Center. (For availability see N74 18797 10 05)

The effectiveness of the U.S. Navy device 24598, a weapons trainer for the P-3A and P-3D aircraft, was investigated. The device provides tactics crews with team training in the detection, tracking, and destruction of modern deep-diving submarines. Careful selection, variation, and control of problem conditions should enable

instructors to train the tactics teams to analyze and respond to situations likely to occur during actual ASW missions. Study results indicate that learning takes place in the simulator and that there is positive transfer to the operational environment. There is room for improvement and modification of the training curriculum. Author

**N74-18802** Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

#### **THE APPLICATION OF AIRCREW OPINIONS ON COCKPIT TASKS AND EQUIPMENT TO FLIGHT SAFETY RESEARCH**

J. M. Rolfe and J. W. Chappelow. In AGARD Behavioural Aspects of Aircraft Accidents. Dec. 1973. 5 p. ref. (For availability see N74 18797 10 05)

A study was conducted to determine the impact of flight crew opinions on flight tasks and aircraft equipment on aircraft accidents which could be related to personnel error. The areas of investigation were: (1) the load imposed on the flight crew in the performance of their duties, and (2) the compatibility between the aircraft equipment and the human limitations and abilities. Tables of data are provided to show the results of a questionnaire submitted to flight crew personnel. Author

**N74 18803** Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

#### **THE PSYCHOLOGIST'S ROLE IN AIRCRAFT ACCIDENT INVESTIGATION**

M. F. Allport. In AGARD Behavioural Aspects of Aircraft Accidents. Dec. 1973. 6 p. (For availability see N74 18797 10 05)

The contributions to be made by psychologists in the reduction of human error aircraft accidents are discussed. Specific areas of cooperation are identified as: (1) analysis of human error accident data; (2) research on human factors aspects of flight safety; and (3) assist in determining the causes of specific aircraft accidents. The advantages of using psychologists in the aircraft accident investigation are reported. Author

**N74 18804** Army Agency for Aviation Safety, Fort Rucker, Ala.

#### **INCIDENCE, COST AND FACTOR ANALYSIS OF PILOT ERROR ACCIDENTS IN US ARMY AVIATION**

Darwin S. Ricketson, Scott A. Johnson, Larry B. Bramham, and Richard F. Dean. In AGARD Behavioural Aspects of Aircraft Accidents. Dec. 1973. 19 p. refs. (For availability see N74 18797 10 05)

From 1959 through 1972 pilot error was a consistently large and costly cause of accidents. Past analysis and prevention efforts have not approached pilot error accidents in the context of malfunctions among the basic man-machine-environment elements. Such an approach was proposed and seeks to identify the common human error events in pilot error accidents. A partial test of this approach was made with helicopter and airplane mishap information in its present form. A factor analysis produced nine distinct, meaningful and representative helicopter and airplane factors. A component score analysis yielded pilot and mishap background information which was helpful in interpreting the factors. An experimental human error events reporting form was developed which holds promise for clearer identification of mishap-causing system elements and corrective measures required. Author

**N74 20732#** Advisory Group for Research, Research and Development, Paris, France.

#### **THE USE OF NYSTAGMOGRAPHY IN AVIATION MEDICINE**

David C. Goodley, Jr. and Flavio Amadori. Med. Res. Serv. Dec. 1973. 184 p. refs. Partly a ERIC report and in ERIC Report presented at the AGARD Aerospace Med. Panel Specialists Meeting, Pensacola, Fla., 14-15 May 1973.

(AGARD CP 128) Avail. NTIS HC \$12.24

Laboratory and clinical applications techniques of nystagmography are reported with emphasis on motion sickness, spatial disorientation, and vertigo as experienced by flying personnel and divers. For individual titles, see N74 20733 through N74 20755.

**N74-20733** Tulane Univ., New Orleans, La. School of Medicine

**CLINICAL APPLICATION OF NYSTAGMOGRAPHY**

Wallace Rubin. In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 3 p. (For availability see N74 20732 12-05)

There are two specific clinical advantages of electronystagmography (ENG). (1) It is possible to detect spontaneous and positional nystagmus that would not be seen without its use, and (2) it is possible to differentiate peripheral from central pathology, and right sided from left sided peripheral lesions, when there is a spontaneous nystagmus. Author

**N74-20734** Minnesota Univ., Minneapolis. School of Medicine

**PRACTICAL PROBLEMS IN CLINICAL NYSTAGMOGRAPHY. 1. GUIDELINES FOR SELECTION OF EQUIPMENT**

Mary Jayne Capps. In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 3 p. refs. (For availability see N74 20732 12-05)

The basic equipment needed for a thorough evaluation of the vestibular system includes an examination chair or table, a polygraphy suitable for recording nystagmus, a device for producing caloric stimuli, and an optokinetic stimulator. The required and optional features of each of these devices have been discussed. The basic equipment will permit the elicitation and recording of the various types of eye movements, i.e. caloric, optokinetic, positional, and spontaneous nystagmus. The evaluation of these phenomena provides a sufficiently complete picture of the state of the vestibular system. Author

**N74-20735** Ohio State Univ., Columbus. Coll. of Medicine

**PRACTICAL PROBLEMS IN CLINICAL NYSTAGMOGRAPHY. 2. SOURCES OF ERROR**

Charles W. Stockwell and William E. Collins (FAA, Oklahoma City). In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 10 p. refs. (For availability see N74 20732 12-05)

The value of clinical nystagmography can be greatly diminished if certain errors are not recognized and avoided. Some errors are introduced by faulty recording techniques, including inadequate calibration, inappropriate choice of frequency filters, and failure to identify artifacts. Other errors are due to the extreme sensitivity of the nystagmus response to extravestibular influences. Caloric testing errors include inadequate stimulus control and failure to account for directional preponderance. These and other errors in nystagmography are pointed out and discussed and corrective measures are suggested. Author

**N74-20736** Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

**USE OF NYSTAGMOGRAPHY IN THE STUDY OF AIRCREW WITH SPATIAL DISORIENTATION**

A. J. Benson. In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 13 p. refs. (For availability see N74 20732 12-05)

Lateral nystagmus evoked by a stopping stimulus of 60 deg/sec was recorded by electro-oculography in 133 aircrew who had come under medical care because of airsickness, spatial disorientation, or other sensory disturbances in flight without illusory perception of aircraft orientation. Measures of the slow phase velocity, the time constant of decay, and total amplitude of the post-rotational nystagmus did not differ between the three groups. Measures of directional preponderance were found to have differences in variance structure between the groups. Measures of directional preponderance were found to have differences in variance structure between the groups, but these were not well defined and hence of limited value in the selection or assessment of individual aircrew. Author

**N74-20737** Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

**A PROPOSED HABITUATION LABYRINTH (PRESENTATION OF SEVERAL RESULTS WITH THE P.N.T.) (A PROPOS DE L'HABITUATION LABYRINTHIQUE (PRESENTATION DE QUELQUES RESULTATS CHEZ LA P.N.T.))**

A. Gilbert, P. Blanc, E. Lafontaine, P. Prieux, and P. Fontelle

In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 7 p. In FRENCH (For availability see N74 20732 12-05)

Several methods, with special emphasis on damp sinusoidal stimulation, used to study labyrinth are introduced. Data are also given on the possible application of these methods in aeronautical and aerospace medicine. Habituation phenomena using the personnel navigation technique are given as well as information obtained by observing the phenomena in the course of professional apprenticeship. The possibility of observing the equilibration function during professional life, particularly during the course and abatement of the central peripheral vertiginous syndrome was discussed. Transl. by E.H.W.

**N74-20738** Hopital d'Instruction des Armees, Versailles (France)

**INTEREST OF NYSTAGMOGRAPHY IN FLYING NAVIGATION PERSONNEL (INTERET DE LA NYSTAGMOGRAPHIE DANS LE PERSONNEL NAVIGATION DE L'AVIATION)**

L. R. Burdes. In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 6 p. In FRENCH (For availability see N74 20732 12-05)

The use of electronystagmography to diagnose psycholabyrinth, hyporeflexive and barotraumatisms vestibulaire and peripheral radicular and central syndromes in navigation personnel is discussed. Test results are included along with data on the possible use of the method as an aid in selecting navigation personnel. Transl. by E.H.W.

**N74-20739** Italian Air Force Aerospace Medical Center, Rome

**A CONTRIBUTION TO THE ELECTRONYSTAGMOGRAPHIC METHOD CONCERNING THE INTERPRETATION OF NYSTAGMUS CHARACTERISTICS**

C. Koch. In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 5 p. refs. (For availability see N74 20732 12-05)

The evaluation of nystagmic characteristics is stressed, both from a quantitative and qualitative standpoint. Descriptions of some of them (amplitude, frequency, duration) are given, the importance of which is well known as far as vestibular semiology and diagnostics are concerned. A new formula is proposed concerning the interpretation of the electronystagmographic recording. This formula makes it easier to define the nystagmus in degrees, thus constituting a basis for its classification. Author

**N74-20740** Illinois Univ., Chicago. Abraham Lincoln School of Medicine

**DIFFERENTIAL DIAGNOSIS OF THE CALORIC NYSTAGMUS**

Nicholas Turok. In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 11 p. refs. (For availability see N74 20732 12-05)

Diagnostic considerations based upon the nystagmogram are limited. Quantitative assessment of horizontal canal sensitivity is available through the use of culmination frequency or culmination slow phase velocity. Three distinctive qualitative features of the caloric nystagmus were evaluated and were found to be suggestive or outright pathognomonic for retrolabyrinthine or central nervous system abnormalities. These are: (1) vestibular decompensation, a disproportionate caloric responsiveness when a weak stimulus elicits a more intense nystagmic reaction than a strong stimulus is capable of creating; (2) hyperactive vestibular responsiveness; and (3) ocular fixation reversal phenomenon. Elimination of fixation decreases the nystagmus intensity instead of facilitating the evoked nystagmus. Author

**N74-20741** McGill Univ., Montreal (Quebec). Dept. of Physiology

**NYSTAGMOGRAPHY: A USEFUL TOOL IN BASIC AND APPLIED INVESTIGATIONS**

G. Melvill Jones. In AGARD The Use of Nystagmography in Aviation Med. Dec 1973 13 p. refs. (For availability see N74 20732 12-05)

Relatively gross eye movements are considered, in particular: (1) quick saccadic gaze shifts from one fixation point to another; (2) the relatively slow smooth pursuit movements associated



with following a fixation point which is moving relative to the head. In many circumstances these two types of movement are integrated to produce a combined pattern of eye movement suitable for intermittent fixation on a visual field which is moving relatively to the head. Methods of recording nystagmus and its data reduction are discussed together with their applicability and hazards in relation to intended objectives. The experimental use of nystagmography is treated in terms of quick and slow phase eye movements and of head movements. Author

**N74-20742** Toronto Univ (Ontario) Dept of Otolaryngology  
**OPTOKINETIC NYSTAGMUS: ITS VALUE IN THE DIAGNOSIS OF CERTAIN VESTIBULAR LESIONS**

Y. Morissette, S. M. Abel, and H. O. Barber. In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 6 p. refs. (For availability see N74-20732 12-05)

Optokinetic nystagmus (OKN) was studied to explore its value in the localization of vestibular lesions. The stimulus consisted of a field of equidistant parallel black bars, either horizontal or vertical, moving across a white ground. The data showed that for subjects with normal vestibular function and unilateral labyrinthectomy, the slow phase velocity of OKN varied nonmonotonically with increases in the speed of the bars between 20 and 400 degrees of visual angle per second. This function reached a single maximum at approximately 60 to 80 degrees of bar velocity for horizontal OKN and at 40 degrees for vertical OKN. In subjects with neurological confirmed lesions of brain stem due to multiple sclerosis, tumor or ischemic disease, the slow phase velocity of OKN did not change but remained constant at about 20 degrees/sec across the range of bar velocities studied. Author

**N74-20743** Mount Sinai Medical and Graduate Schools, New York. Dept. of Neurology

**VISUAL-VESTIBULAR INTERACTION: THE ROLE OF THE LABYRINTH IN THE PRODUCTION OF OPTOKINETIC NYSTAGMUS AND OPTOKINETIC AFTER NYSTAGMUS**  
B. Cohen, S. Takemori, and T. Uemura. In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 4 p. refs. (For availability see N74-20732 12-05)

OKN and OKAN were affected by unilateral and bilateral labyrinthectomy. The maximum velocity of slow phases of OKN induced by drum rotations above 60-75 deg/sec in either direction was lower after unilateral and bilateral labyrinthectomy. The frequency of OKN was also decreased, and the total deviation of the eyes was reduced for OKN induced by these drum speeds. Changes in OKN eventually recovered. OKAN was reduced in duration after unilateral labyrinthectomy, being initially shorter to the ipsilateral than to the contralateral side. OKAN could no longer be evoked after bilateral labyrinthectomy. This loss was permanent. These data demonstrate the importance of the vestibular system in maintenance of OKN and OKAN. Author

**N74-20744** Freiburg Univ (West Germany) Dept. of Neurology and Neurophysiology

**SELF-MOTION SENSATION, PSEUDO CORIOLIS EFFECTS AND MOTION SICKNESS INDUCED BY OPTOKINETIC STIMULI**

Johannes Dichgans and Thomas Brandt. In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 3 p. refs. (For availability see N74-20732 12-05)

Psychophysiological experiments reported establish that the human sensation of self motion is evoked by stimulation of the labyrinthine receptors as well as by excitation of the visual sense. Circulation, pseudo coriolis effect, and visually induced tilt of the apparent vertical produce oculog-av. motion illusions and motion sickness phenomena due to vestibular-visual interaction. G.G.

**N74-20745** Miami Univ, Oxford, Ohio. Dept. of Psychology

**EFFECTS OF SOUND ON THE VESTIBULAR SYSTEM**  
D. E. Parker, M. F. Reschke, and R. L. Tubbs. In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 12 p. refs. (For availability see N74-20732 12-05)

(Contracts F33615-69 C-1246, F33615-73 C-4002)

The effects of sound on the vestibular systems of guinea

pigs and monkeys were studied. Sound stimuli included: (1) Pressure transients, (2) infrasounds, and (3) intense audiofrequency sound. Biomechanical and physiological responses to these three types of stimuli were observed. Biomechanical responses examined included stapes displacement and perilymph pressure changes. Vestibular nerve activity, eye movements, and head movements are the physiological responses that were recorded. Monkey responses differed from guinea pig responses under several conditions; response differences suggest different mechanisms of acoustical vestibular stimulation in these two species. Author

**N74-20746** Florida Univ, Gainesville. Div. of Otolaryngology

**NORMAL LIMITS FOR THE SEQUENTIAL BITHERMAL BINAURAL CALORIC TEST**  
Franklin O. Black, David D. Custer (Tech. Vocational Inst.), William G. Hemenway (Colo. Univ.), and John I. Thornby. In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 9 p. refs. (For availability see N74-20732 12-05)

Analysis of bithermal binaural caloric test results gave a statistically significant response difference between ears for right handed normal subjects. There were no significant response differences due to temperature of stimulation and ear stimulated. Three tests for the determination of caloric nystagmus response abnormalities were developed, based upon analysis of intrasubject normal responses. A retrospective examination of caloric responses from patients with Meniere's disease provided preliminary support for clinical feasibility and increased sensitivity of the statistical methods advocated for clinical usage. Author

**N74-20747** Mainz Univ (West Germany) Dept. of Physiology

**HUMAN EYE MOVEMENTS DURING VARIOUS FORMS OF LINEAR ACCELERATION AND WEIGHTLESSNESS**

R. J. Von Baumgarten, R. Thumler (Mich. Univ.), C. L. Shilling Jr. (NASA Ames Res. Center), and G. Baldrighi (Mich. Univ.). In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 3 p. refs. (For availability see N74-20732 12-05)

Eye movements of human subjects were recorded electronically, stigmographically in complete darkness during rectilinear horizontal accelerations as achieved in cars on the ground and also during aircraft parabolic flight. The results were compared to the movements of blinded goldfish subjected to similar changes of gravito-inertial forces. The results indicate that there is a human correlation with the gravity reference response of fish. During horizontal forward accelerations on the ground the human eyes turn downward and during horizontal backward acceleration the eyes turn upward. The human eye response to g loads below 1 g and to weightlessness is the reverse of the tilt of the fish. While fish dive down during low g or loop forward during weightlessness, the eyes of subjects sitting upright in an aircraft which flies at 0 g move upward. Author

**N74-20748** Ludwig-Maximilians-Universität, Munich (West Germany)

**THERMOELECTRIC STIMULATION OF THE LABYRINTH**  
Hans Scherer. In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 5 p. (For availability see N74-20732 12-05)

A new method of caloric labyrinth stimulation is described. The use of water as a stimulator is replaced by a copper plug positioned in the external ear canal. The plug's temperature is regulated by Peltier thermoelectric plates which are connected with a power supply and are able to produce on one of their sides either heat or cold. Every temperature necessary to stimulate the labyrinth can be applied. Electronic steering and the automatization of the whole test are easily applicable. The new method is especially useful in patients with lesions of the ear drum. Several typical examples of thermoelectric stimulation of the labyrinth and the nystagmic response are shown. Author

**N74-20749** Ulm Univ (West Germany) Dept. of Neurology

**COMPUTER-ELECTRONYSTAGMOGRAPHY IN EVALUATING THE INFLUENCE OF PSYCHOPHARMACOLOGICAL DRUGS ON VIGILANCE**  
Juergen C. Aschoff and Wolfgang Becker. In AGARD: The Use of Nystagmography in Aviation Med. Dec. 1973. 8 p. refs. (For availability see N74-20732 12-05)

Maximum velocity and duration of saccadic eye movements depend entirely on the magnitude of angular deflection of the eye ball, and on the state of alertness or fatigue. Tranquilizing drugs such as Diazepam are known to reduce significantly the maximum velocity, but accuracy and reaction time of these eye movements deteriorate, too. For evaluating these drugs, an on-line computer program has been developed whereby 500 saccadic eye movements are computed for their maximum velocity, duration, accuracy and reaction time. All desired parameters are plotted in amplitude subgroups with mean values - or - standard deviation. Various drugs have been tested using this method including a powerful new antidepressant drug Sulpride. This antidepressant psychopharmakon showed no influence on velocity and reaction time and may even enhance accuracy of saccadic eye movements. Author

**N74-20750** School of Aerospace Medicine, Brooks AFB, Tex. Clinical Sciences Div.  
**AEROMEDICAL RESEARCH AND CLINICAL APPLICATIONS OF AVERAGING TECHNIQUES IN NYSTAGMOGRAPHY**

James W. Wolfe. In AGARD. The Use of Nystagmography in Aviation Med. Dec 1973. 6 p. refs. (For availability see N74-20732 12-05)

A system employing analog-to-digital techniques has been developed for simultaneously measuring the average slow and fast phase velocity of the summated response and left and right eye movements separately and for precisely resolving both of these variables. This method is described along with illustrative cases. Preliminary results indicate that this approach may be useful in differentiating peripheral and central vestibulo-oculomotor pathology. Author

**N74-20751\*** Massachusetts Inst. of Tech. Cambridge. Man-Vehicle Lab.

**AUTOMATED NYSTAGMUS ANALYSIS**

Charles M. Oman, John H. J. Allum, John R. Tole, and Laurence R. Young. In AGARD. The Use of Nystagmography in Aviation Med. Dec 1973. 9 p. refs. (For availability see N74-20732 12-05)

(Grants NGR-22-009-025, NGR-22-009-156, NGR-22-009-701)

Several methods have recently been used for on-line analysis of nystagmus. A digital computer program has been developed to accept sampled records of eye position, detect fast phase components, and output cumulative slow phase position, continuous slow phase velocity, instantaneous fast phase frequency, and other parameters. The slow phase velocity is obtained by differentiation of the calculated cumulative position rather than the original eye movement record. Also, a prototype analog device has been devised which calculates the velocity of the slow phase component during caloric testing. Examples of clinical and research eye movement records analyzed with these devices are shown. Author

**N74-20752** Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

**A MODEL FOR THE PREDICTION OF THE NYSTAGMIC RESPONSE TO ANGULAR AND LINEAR ACCELERATION STIMULI**

G. R. Barnes and A. J. Benson. In AGARD. The Use of Nystagmography in Aviation Med. Dec 1973. 13 p. refs. (For availability see N74-20732 12-05)

A model has been developed for the mechanism of saccadic generation in the vestibulo-ocular reflex arc, in an attempt to explain variations in the pattern of nystagmic response to vestibular stimulation. The model has been developed using an analogue computer and an attempt has been made to relate the system to the known physiological evidence. The response of the model has been compared with results from experiments on human subjects, and satisfactory agreement has been obtained in conditions appropriate to stimulation of the canals by both periodic and transient angular accelerations and to stimulation of the utricular maculae by linear acceleration. The model effectively simulates the changes in frequency and duration of slow phase and saccadic eye movements observed experimentally. Author

**N74-20753** Royal Australian Navy School of Underwater Medicine, Balmoral

**VERTIGO IN DIVING**

Carl Edmonds. In AGARD. The Use of Nystagmography in Aviation Med. Dec 1973. 10 p. refs. (For availability see N74-20732 12-05)

Because vertigo is associated with nystagmus and this can be demonstrated in an objective manner, it has been attempted to differentiate the specific causes of vertigo from those of disorientation in general. It is fully appreciated that there is a strong correlation between these two symptoms. An aetiological classification of vertigo in diving is reported that considers aspects of unequal vestibular stimulation as well as unequal vestibular responses. Author

**N74-20754** Duke Univ., Durham, N.C. Div. of Otolaryngology.  
**COCHLEAR AND VESTIBULAR INJURIES DURING DIVING**

Joseph C. Farmer, Jr. In AGARD. The Use of Nystagmography in Aviation Med. Dec 1973. 8 p. refs. (For availability see N74-20732 12-05)

Cochlear and vestibular damage can occur during all phases of diving. Inner ear damage during compression seems to be related to difficulties with middle ear pressure equalization while such damage occurring at stable deep depths seems to be related to experimental changes in inspired inert gas composition. Cochlear and vestibular damage during decompression seems to be a form of decompression sickness and can be the only manifestation of this problem. Twenty cases of such damage are presented in which there is a significant correlation between prompt recompression treatment and lack of residual deficits. Excessive noise is not uncommon during various diving conditions and can lead to temporary and presumably permanent auditory thresholds shifts. Author

**N74-20755** Lund Univ. (Sweden). ENT-Dept.  
**EFFECTS OF INCREASED MIDDLE EAR PRESSURE ON THE VESTIBULAR SYSTEM**

Oerjan Tjernstrom. In AGARD. The Use of Nystagmography in Aviation Med. Dec 1973. 9 p. refs. (For availability see N74-20732 12-05)

A technique is described for measuring changes in pressure in the middle ear. Fitted to the external ear canal is a rubber cuff which contains a small tube. A flowmeter, parallel with the tube, detects airflow between the external ear canal and the ambient air. The airflow is compared electronically with a reference airflow in another tube which emanates from an adjustable reference volume. By recording in this manner in a pressure chamber, pressure changes in the middle ear could be related to report vertigo and also to recorded nystagmus. Results indicate that alternobaric vertigo (A.V.) may occur with only moderate pressure changes and that some subjects who would otherwise be regarded as normal are especially susceptible to A.V., apparently as a result of a high forcing pressure on one side. Author

**06 CHEMISTRY**

Includes chemical analysis and identification (e.g. spectroscopy). For applications see 17 Materials, Metallic; 18 Materials, Nonmetallic; and 27 Propellants

**N73-31830/** Advisory Group for Aerospace Research and Development, Paris (France).

**GAS SAMPLING AND ANALYSIS IN COMBUSTION PHENOMENA**

G. Langelle (ONERA, Paris) and C. Verdier (ONERA, Paris) Jul. 1973 185 p refs

(AGARD-AG-168; AGARDOGRAPH-188) Avail: NTIS HC \$11.25

The application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers is discussed. The fundamental data for combustion kinetics in a perfectly stirred reactor and in premixed laminar flames are reported. Various methods of gas analysis using gas phase chromatography, mass spectrometry, absorption of electromagnetic radiation, absorption of electromagnetic radiations, and physicochemical methods of flow-through analysis are explained. Author

**N74-22799/** Advisory Group for Aerospace Research and Development, Paris (France).

**GAS SAMPLING AND ANALYSIS IN COMBUSTION PHENOMENA [PRELEVEMENT ET ANALYSE DE GAZ DANS LES PHENOMENES DE COMBUSTION]**

G. Langelle (ONERA, Paris) and C. Verdier (ONERA, Paris) Jul. 1973 187 p refs In FRENCH

(AGARDograph-168(FR); AGARD-AG-168(FR)) Avail: NTIS HC \$12.50

The application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers is discussed. The fundamental data for combustion kinetics in a perfectly stirred reactor and in premixed laminar flames are reported. Various methods of gas analysis using gas phase chromatography, mass spectrometry, absorption of electromagnetic radiations, and physicochemical methods of flow-through analysis are explained. Author

## 07 COMMUNICATIONS

Includes communications equipment and techniques, noise, radio and communications blackout, modulation, telemetry, tracking radar and optical observation, and wave propagation. For basic research see 23 Physics, General, and 21 Navigation

**N71-19528#** Advisory Group for Aerospace Research and Development, Paris (France)  
**INFORMATION ANALYSIS CENTRES**  
 Feb. 1971 59 p refs. Conf. held at Amsterdam 10 Nov 1970 (AGARD-CP-78-71) Avail NTIS

## CONTENTS

1 CONCEPT MISSION AND OPERATION OF SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS J W Murdock (Battelle Memorial Inst., Columbus, Ohio) 14 p (See N71-19527 09-07)

2 FUNDING INFORMATION ANALYSIS CENTERS G S Simpson, Jr (Battelle Memorial Inst., Columbus, Ohio) 4 p (See N71-19528 09-07)

3 A SPECIALIZED DOCUMENTATION CENTER ITS ORGANIZATION, ITS METHODS, ITS EFFECTIVENESS Y J Roeper (Societe Nationale Industrielle Aerospatiale, Paris, France) 11 p (See N71-19529 09-07)

4 THE HARWELL HEAT TRANSFER AND FLUID FLOW INFORMATION ANALYSIS CENTRE L B Cousins (UKAEA, Harwell, England) 8 p (See N71-19530 09-33)

5 PROPOSAL FOR AN INTERNATIONAL AIR POLLUTION INFORMATION ANALYSIS CENTER J W Murdock (Battelle Memorial Inst., Columbus, Ohio) 5 p (See N71-19531 09-13)

6 MARITIME POLLUTION R P Langston (Admiralty Oil Lab., Cobham, England) 7 p refs (See N71-19532 09-13)

**N71-19527#** Battelle Memorial Inst., Columbus, Ohio  
**CONCEPT, MISSION, AND OPERATION OF SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS**  
 J W Murdock. In AGARD Inform. Analysis Centres Feb 1971 14 p (See N71-19528 09-07)  
 Avail NTIS

A discussion is given of the fundamental concepts of an information analysis center (IAC) and how it relates to other information services. The mission of an IAC is considered in terms of how unpublished information is obtained and used, and how feedback helps the IAC achieve its goals. Operational aspects of a center are reviewed, and experiences by research scientists and engineers in utilizing an IAC are related. Two non-government supported IACs are described along with one government center. The advantages of working in an IAC environment, key problems in day-to-day operation, and the ever present problem of money are included in the discussion. D L G

**N71-19528#** Battelle Memorial Inst., Columbus, Ohio  
**FUNDING INFORMATION ANALYSIS CENTERS**  
 G S Simpson, Jr. In AGARD Inform. Analysis Centres Feb 1971 4 p (See N71-19526 09-07)  
 Avail NTIS

An overview is presented of the funding problems involved in the implementation and maintenance of an information analysis center. It is pointed out that (1) the centers are expensive to operate, (2) adequate funding is difficult to obtain and keep, and (3) the centers cannot be economically justified for every aspect of science and engineering. Another basic problem involves the difficulty in acquiring detailed data cost from facilities that are presently in operation. Emphasis of the discussion is placed on factors that determine whether an information analysis center is

needed, what size it should be, and whether it should be funded by government sources or private industry. D L G

**N71-19529#** Societe Nationale Industrielle Aerospatiale, Paris (France) Div Systemes Balistiques et Spatiaux  
**A SPECIALIZED DOCUMENTATION CENTER: ITS ORGANIZATION, ITS METHODS, ITS EFFECTIVENESS (UN CENTRE DE DOCUMENTATION SPECIALISE: SON ORGANISATION, SES METHODES, SON EFFICACITE)**  
 Y J Roeper. In AGARD Inform. Analysis Centres Feb 1971 11 p. In FRENCH, ENGLISH summary (See N71-19528 09-07)  
 Avail US Patent Office

The establishment and operation procedures are described for a documentation center dealing with aerospace data. Discussions are given concerning (1) the need for such a center, (2) the documentation chain employed, (3) the automation involved, and (4) cost effectiveness. In addition, some figures are provided to illustrate the cost of automatic documentation. D L G

**N71-19530#** United Kingdom Atomic Energy Authority, Harwell (England)

**THE HARWELL HEAT TRANSFER AND FLUID FLOW INFORMATION ANALYSIS CENTRE**

L B Cousins. In AGARD Inform. Analysis Centres Feb 1971 (See N71-19526 09-07) 8 p  
 Avail NTIS

The establishment of a service to meet the information requirements of a specific group of scientists and technologists is described. The setting up of a reference library for heat transfer and fluid flow literature is outlined, and the methods employed for rapid retrieval of that literature using a large digital computer are given. Author

**N71-19531#** Battelle Memorial Inst., Columbus, Ohio  
**PROPOSAL FOR AN INTERNATIONAL AIR POLLUTION INFORMATION ANALYSIS CENTER**

John W Murdock. In AGARD Inform. Analysis Centres Feb 1971 5 p (See N71-19526 09-07)  
 Avail NTIS

The establishment within NATO of an international information analysis center on air pollution is proposed. The application of information analysis concepts to this critical field, which increasingly involves multidisciplinary research and development efforts in all the industrialized societies of the world, would create a comprehensive base of knowledge that would be utilized by (1) research scientists of many nations to assure maximum effective contributions to solving air pollution problems and (2) by administrators and policy makers to make the major decisions that determine what research is to be done and how it is to be funded. Methods of establishing the information analysis center, its organization, and the functions of its international staff are described. Author

**N71-19532#** Admiralty Oil Lab., Cobham (England)  
**MARITIME POLLUTION**

R P Langston. In AGARD Inform. Analysis Centres Feb 1971 7 p refs (See N71-19526 09-07)  
 Avail NTIS

A discussion is presented on the feasibility of an international maritime pollution information analysis center. Emphasis is placed on the growing recognition of the need for a better understanding of what takes place when oil products are spilled at sea. The proposed center would process, on an international basis, all data dealing with the nature of oil spills, the consequences, and the technologies employed in the cleaning up process. In addition, incidences of oil spillage would be reported to the center and this information would be routinely processed and disseminated to all member countries. Other benefits that could be derived from the proposed center are briefly discussed and include (1) the acquisition of data on weather conditions and water movements, (2) the

availability of industrial and ecological information, (3) the identification of pollutants, and (4) the formulation of legal aspects and medical/toxic aspects. D L G

**N71-21408#** Advisory Group for Aerospace Research and Development, Paris (France)

**TROPOSPHERIC RADIO WAVE PROPAGATION, PART 1 Conference Proceedings**

H. J. Albrecht, ed. Feb. 1971. 309 p. refs. Mostly in ENGLISH, partly in FRENCH. AGARD Avionics Panel 16th Tech. Symp. held in Dusseldorf, 31 Aug - 4 Sept 1970.

(AGARD-CP-70-71-Ft-1) Avail NTIS

Electromagnetic wave propagation through the troposphere is analyzed for the effects of tropospheric characteristics on wave reflection and refraction, scatter propagation, and propagation prediction methods. For individual titles, see N71-21410 through N71-21433.

**N71-21410#** Advisory Group for Aerospace Research and Development, Paris (France). Communications Electronics Div. of the Military Committee

**MILITARY APPLICATIONS OF RESEARCH AND DEVELOPMENT IN TROPOSPHERIC WAVE PROPAGATION**

Enrico Scotti (Italian Army). In *its* Tropospheric Radio Wave Propagation, Pt. 1 Feb. 1971. 4 p. (See N71-21409 10-07)

Avail NTIS

An overview of military applications of tropospheric propagation phenomena in scatter communications and radar is presented with emphasis on the problems encountered by military communications, sensor systems command and control, frequency planning and the NATO integrated communications system is discussed. A better correlation of the known aspects of tropospheric propagation so as to best support military systems planning is advocated. Author

**N71-21411#** Advisory Group for Aerospace Research and Development, Paris (France)

**THE STRUCTURE AND DYNAMICS OF THE TROPOSPHERE**

P. Keethjen. In *its* Tropospheric Radio Wave Propagation, Pt. 1 Feb. 1971. 12 p. (See N71-21409 10-07)

Avail NTIS

A three-fluids general atmospheric circulation model is described that uses a large rotating water bowl to realize Prandtl's theoretical atmospheric flow model. Experimental results obtained with the water basin containing three liquids of differing densities indicate that a weak meridional flow polewards is the cause of strong western winds. Atmospheric cyclones at higher latitudes originate where an upper branch of meridional circulation, far advanced in a direction towards the pole, commences its descent. G G

**N71-21412#** Environmental Science Services Administration, Boulder, Colo.

**WORLDWIDE CHARACTERISTICS OF REFRACTIVE INDEX AND CLIMATOLOGICAL EFFECTS**

B. R. Bean, B. A. Hart, and G. D. Thayer. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb. 1971. 14 p. refs. (See N71-21409 10-07)

Avail NTIS

The development and present status of radio climatology are reviewed, from Newton's use of the exponential atmosphere to recent work on the climatology of radio refractive index turbulence. (1) development of models of the general vertical structure of the refractive index with a three-part exponential profile, (2) the general refractive index gradient, elevated layers with strong refractive index gradients, and winds in the common volume region which are significant to the performance of transhorizon radio propagation systems, (3) studies of the climatology of the initial gradient of the radio refractive index which have revealed that the

tropical areas of the world experience the most severe conditions, and (4) the likelihood of turbulence of the radio refractive index as determined from the gradient of the potential refractive index and calculated from conventional meteorological soundings of the atmosphere. Author

**N71-21413#** General Electric Co., Syracuse, N.Y.

**TROPOSPHERIC EFFECTS ON SPACE COMMUNICATIONS**

George H. Millman. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb. 1971. 30 p. refs. (See N71-21409 10-07)

Avail NTIS

The influence of the natural environment is considered in the design of an earth satellite communication system. The nonisotropic characteristics of the troposphere are evaluated in terms of their effects on the propagation of electromagnetic waves through the medium. The tropospheric propagational phenomena which are discussed are refraction, time delay, scintillation effects, doppler frequency shift, ducting, attenuation, and noise. Author

**N71-21414#** Stanford Research Inst., Calif. Aerophysics Lab.

**SATELLITE VIEWED CLOUD COVER AS A DESCRIPTOR OF RADIO-RADAR PROPAGATION CONDITIONS**

R. H. Blackmer Jr. and S. M. Serebreny. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb. 1971. 12 p. (See N71-21409 10-07)

Avail NTIS

Comparison is made between the appearance of a satellite viewed cloud cover and radio-radar propagation conditions to determine whether cloud cover can describe atmospheric conditions influencing radio-radar propagation. Radar performance records from the eastern Pacific Ocean and tropospheric scatter signals from the southwestern Pacific ocean were compared with satellite photographs of cloud cover over the respective areas. It is shown that the nature of the cloud cover helps to indicate whether propagation will be normal or abnormal but more research is needed to obtain quantitative propagation data over small scale areas. Author

**N71-21415#** Air Force Cambridge Research Labs., Bedford, Mass.

**RAIN ATTENUATION AT MILLIMETER WAVELENGTHS**

E. E. Altshuler, V. J. Falcone, and K. N. Wulfsberg. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb. 1971. 10 p. refs. (See N71-21409 10-07)

Avail NTIS

A program to determine the feasibility of using millimeter waves for space communication has been conducted and it has been shown that at 15 and 35 GHz atmospheric attenuation is relatively low except for conditions of heavy clouds and precipitation. Rain attenuation was measured in Hilo, Hawaii and the following results were obtained: (1) total atmospheric attenuation is moderately low at 15 and 35 GHz for rainfall rates less than 1 mm/hr and zenith angles less than 45 deg. For higher rainfall rates and angles closer to the horizon the attenuation becomes prohibitive, particularly at 35 GHz, (2) total atmospheric attenuation can be accurately calculated from a measurement of apparent sky temperature, and (3) atmospheric attenuations at 15 and 35 GHz are highly correlated. Author

**N71-21416#** McGill Univ., Montreal (Quebec)

**APPLICATION OF WEATHER RADAR DATA TO PROPAGATION QUESTIONS**

R. R. Rogers. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb. 1971. 11 p. refs. Supported by Can. Dept. of Commun. (See N71-21409 10-07)

Avail NTIS

The weather radar facility instrument provides a real time

display of the 10GHz attenuation due to rain along the radar line of sight. Three months' data from two summers have been analyzed to give attenuation statistics for application to communications over terrestrial and satellite microwave links. Preliminary results are presented for the azimuth extent, duration, and frequency of occurrence of attenuations ranging from 5 to 30 GHz at elevation angles between 3 deg and 20 deg. Author

**N71-21417# Communications Research Centre, Ottawa (Ontario)  
SIMULTANEOUS MEASUREMENTS OF PRECIPITATION  
ATTENUATION AND RADAR REFLECTIVITY AT  
CENTIMETRE WAVELENGTHS**

K. S. McCormick. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb 1971. 12 p refs. (See N71-21409 10-07)  
Avail. NTIS

Measurements have been made of precipitation attenuation along slant paths through the troposphere. Beacons at 4, 8 and 15 GHz were carried by an aircraft which flew in circular paths around a receiving antenna, with elevation angles to the aircraft for different flights between 3 and 20 degrees. Simultaneous measurements of backscatter from precipitation along the propagation path were made using a 2.9 GHz weather radar. The radar data have been used to calculate values of the path attenuation, using empirical relations to relate attenuation to reflectivity factor. Data were obtained for situations including moderate widespread rain, an intense shower, rain cells which apparently contained hail in their cores, and situations in which a distinct melting layer was present. On the basis of the measured data, it is concluded that the radar can be used to calculate values of path attenuation that give satisfactory agreement with the observed values, provided that hail or a melting layer is not intercepted by the radar beam. Author

**N71-21418# Texas Univ., Austin. Electrical Engineering Research  
Lab**

**COMPARISON OF 15 GHz PROPAGATION DATA FROM  
THE ATS-5 SATELLITE WITH GROUND BASED RADIO  
AND METEOROLOGICAL DATA**

A. W. Straton and G. M. Fannin. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb 1971. 10 p refs. (See N71-21409 10-07)

Avail. NTIS

15 GHz signals transmitted from the ATS-5 satellite and related ground based observations are discussed. The purpose of the experiments is to determine the reliability and predictability of communication from space at frequencies higher than presently used. The ATS-5 satellite was put in synchronous orbit at 108 deg West longitude. Failure in one of the positioning jets prevented stabilization with a resulting rotation 76 cycles per minute. However, it was possible to determine significant information on the transmission characteristics of the atmosphere. Various ancillary data were taken including wind speed and direction, temperature, rain rate and distribution, sky temperature and surface radio wave attenuation. Author

**N71-21419# Communications Research Centre, Ottawa (Ontario)  
MICROWAVE ATTENUATION MEASUREMENTS USING  
THE ATS-5 SATELLITE**

J. I. Strickland and J. W. B. Day. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb 1971. 7 p refs. (See N71-21409 10-07)

Avail. NTIS

The attenuation by precipitation a 15.3 GHz signal is being measured for slant paths of 30 degrees elevation angle using the beacon transmissions of the ATS-5 satellite. The sky temperature at 15.3 GHz along the propagation path is measured simultaneously with a total power radiometer. Predicted attenuations are calculated from measured values of the sky temperature. Backscatter of radiation of 2.9 GHz is measured with a collocated S-band radar. Values of mean radar reflectivity are calculated and path

attenuations at 15.3 GHz derived. Generally good agreement between radiometer predicted, radar predicted, and directly measured attenuations is obtained. Author

**N71-21420# Max-Planck-Institut für Aeronomie, Lindau über  
Nörthheim (West Germany). Abteilung Weltraumphysik  
INFLUENCE OF THE TROPOSPHERE ON LOW INCIDENT  
SATELLITE SIGNALS IN THE RANGE OF WAVELENGTH  
15 TO 2 m**

G. K. Hartmann. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb 1971. 11 p. (See N71-21409 10-07)  
Avail. NTIS

The amplitude of radio signals from the beacon satellite Explorer 22 has been recorded since November 1964 for the purpose of obtaining the ionospheric electron content from the Faraday effect. On a considerable number of occasions when the satellite was at low elevation angles, sudden increases in signal amplitude were observed. Detailed investigations show that these enhancements are the results of diffractions of the radio waves by structures within the troposphere. These effects were observed on 20 MHz, 40 MHz, 41 MHz and 136 MHz. Detailed investigations of Explorer 22 records from 1965-1968 revealed that about 6% of all recordings showed these tropospheric effects. Very recent observations with signals from the geostationary satellite ATS-3 on 137.350 MHz and 412.05 MHz clearly demonstrated that similar effects were detectable. Author

**N71-21421# Forschungsinstitut für Hochfrequenzphysik, Bonn  
(West Germany)**

**TROPOSPHERIC PATH PARAMETERS WITH MULTIPLE  
ACCESS SYSTEMS IN SPACE COMMUNICATIONS**

H. J. Albrecht and R. Makruschka. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb 1971. 19 p. Sponsored by Min. of Defence, Federal Rep. of Ger. (See N71-21409 10-07)  
Avail. NTIS

Design aspects for optimized multiple access systems with reference to variable tropospheric conditions are discussed. Particular mention is made of frequency division multiple access (FDMA), time division multiple access (TDMA), and code division multiple access (CDMA). The tropospheric parameters which are likely to influence the choice of the multiple access systems, as for instance turbulence with variable turbulence characteristics, layer-like occurrences in the lower and upper troposphere, and effects of ground inversion layers are described. In each case, the dependence of the tropospheric path links upon the effective elevation angle of operation is considered a major criterion. Author

**N71-21422# Air Force Systems Command, Wright-Patterson  
AFB, Ohio. Avionics Lab**

**THE EFFECT OF THE PROPAGATION MEDIUM ON HIGH  
DATA RATE TRANSMISSIONS AT LOW ELEVATION  
ANGLES**

W. T. Hunt. In AGARD Tropospheric Radio Wave Propagation, Pt. 1 Feb 1971. 9 p refs. (See N71-21409 10-07)  
Avail. NTIS

A radio wave passing through a turbulent propagation medium such as the troposphere, suffers distortions which are equivalent to the generation of new signals or propagation medium noise. The desired signal will be modulated, causing unwanted noise and erroneous interpretation of the received signals. This problem increases greatly when one or both terminals are moving rapidly through turbulent media. The problem is greatly accentuated at elevation angles of less than 10 degrees because of the longer path the signal has to travel through the troposphere and because of multipath effects. Aircraft-to-ground tests at S-band frequencies utilizing a 250,000 bit/sec rate and satellite-to-ground tests at X-band frequencies have been conducted at bandwidths of 8 MHz. These tests are described and some of the results are summarized. Author

**N71-21423#** Radio and Space Research Station, Slough (England)

**EFFECTS OF TROPOSPHERIC LAYER STRUCTURE ON PROPAGATION AND SIGNAL DISTORTION**

J. A. Lane /In AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 14 p refs (See N71-21409 10-07)

Avail NTIS

The nature of elevated layers of large vertical gradient of refractivity in the troposphere is discussed. In addition to earlier observations with refractometers on aircraft, much important information has been obtained with balloon-borne instruments, optical radar (lidar), acoustic radar, and centimeter radar of high resolution. Some degree of stratification in the first few kilometers above ground is now known to be relatively common, but the precise effect of such stratification on signal strength, fading characteristics, Doppler spectrum, available bandwidth, space diversity and gain degradation has been investigated in relatively few investigations. The significance of dynamic stability is discussed and recent experiments of special importance are reviewed in relation to those results which are especially relevant to the physical nature of layer structure and theories of turbulence. Author

**N71-21424#** Environmental Science Services Administration, Boulder, Colo.

**REFLECTIONS FROM ELEVATED LAYERS IN TRANSHORIZON RADIO PROPAGATION**

Gordon D. Thayer /In AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 14 p refs (See N71-21409 10-07)

Avail NTIS

Computations of the power reflection coefficient  $R$  for some tropospheric elevated layers observed with radio refractometers show that the mean  $R$  varies. Fluctuation values from the  $\chi^2$  to the minus 1 power dependence with standard deviations of from 3 to 14 db depend on the degree of smoothness assumed in predicting a scatter in the wavelength dependence as obtained from scaled frequency-diversity transhorizon radio experiments. The mean wavelength dependence derived from the  $\chi^2$  to the minus 1 power model and the exact value depend on assumptions about the horizontal dimensions of individual layers compared with the size of the Fresnel zones. Published results indicate that the atmosphere consists of a mixture of large and medium layers. The randomness of the  $\chi^2$  dependence of real tropospheric layers makes it difficult to separate layer and turbulence mechanisms in radio propagation experiments. Author

**N71-21425#** Saarland Univ, Saarbrücken (West Germany) Inst for Applied Physics and Electrotechnology

**PROPAGATION OF AN ELECTROMAGNETIC PULSE IN A DUCT BETWEEN GROUND AND ATMOSPHERIC LAYER**

K. J. Langenberg /In AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 13 p refs (See N71-21409 10-07)

Avail NTIS

The influence exerted onto an electromagnetic pulse by an atmospheric surface duct is studied based on a duct model consisting of a layer of relative permittivity overlying an infinitely conducting plane earth. At the height  $h$  this permittivity decreases discontinuously to the value  $\epsilon_{\text{sub } 2}$ . The source of the electromagnetic field is assumed to be a vertical magnetic dipole above the surface of the earth with arbitrary time varying moment. The application of a Hankel transform of zero order leads to an integral representation of the Fitzgerald vector in the imaging space of a Fourier transform describing the received signal at some point in a cylindrical coordinate system. The Fourier reverse transform of the modal expansion is calculated approximately by the method of stationary phase giving a clear picture of the characteristics of an incoming signal with the aid of the group velocity concept. Author

**N71-21426#** Radio and Space Research Station, Slough (England)

**TRANSHORIZON PROPAGATION STUDIES AT VHF AND UHF**

M. P. M. Hall /In AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 10 p refs (See N71-21409 10-07)

Avail NTIS

Measurements made to examine propagation modes producing considerable signal enhancement over the long-term median on a VHF transhorizon path are discussed. Meteorological measurements were made near the path center using a specially made radiosonde beneath a tethered balloon. Two examples are considered. On one the propagation mode changed twice within three hours, on the other the propagation mode remained constant despite a steady drop in signal of 10 db. Author

**N71-21427#** Hamburg Univ (West Germany) Meteorological Inst

**PROPAGATION, 18 GHz AND 17 GHz, ON A TRANSHORIZON PATH OVER SEA**

H. Jeske /In AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 10 p refs (See N71-21409 10-07)

Avail NTIS

Transmission measurements were carried out on transhorizon paths over sea at wave lengths of 1.8 cm and 4.4 cm. During the experiments the radio field strengths and the meteorological data for the determination of the propagation properties were recorded simultaneously. The dominating feature of C band propagation over sea is ducting by a permanently existing low level evaporation duct. The theoretical and experimental dependence of field strength on the thickness of this evaporation duct is discussed. The duct mechanism is clearly identified. Only occasionally (in about 15% of time) the stratification of higher layers becomes predominant. Author

**N71-21428#** Hamburg Univ (West Germany) Inst for Radiometeorology

**DUCT INFLUENCES ON LINE OF SIGHT PROPAGATION**

H. W. Fruechtenicht /In AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 9 p (See N71-21409 10-07)

Avail NTIS

The influence of surface ducts on line-of-sight propagation of electromagnetic waves is investigated by model calculations. The theoretical considerations are based on ray-tracing techniques. A linear, parabolic, and a logarithmic profile as well as a two-layer model and a three-layer model are employed to calculate the total field. Obviously only the beam reflected at the surface of the earth gives rise to a concentration of the electromagnetic energy inside a tube-like structure near the ground. The existence of the surface duct, however, is by no means sufficient for the development of the focusing effect; the surface of the earth is necessary as additional reflector. The theoretical dependence of the signal strength on the duct thickness according to a three layer model corresponds with the experiment. Author

**N71-21429#** Research Inst of National Defence, Stockholm (Sweden)

**BEYOND THE HORIZON PROPAGATION OVER SEA AT 170 AND 5000 MHz**

F. Eklund, A. Blomquist and L. Nilsson /In AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 6 p (See N71-21409 10-07)

Avail NTIS

Investigations of anomalous propagation have been made at 170 and 5000 MHz over a sea path in the Baltic area of such a length that the receiving antennas were well beyond the radio horizon. The received signals are separated into the following types: standard atmosphere signals (tropospheric scatter signal), stable and not stable signals caused by ducting or reflections in

elevated layers. A comparison of the occurrence of different signal types as a function of the time of the year is given. The signals at 170 and 5000 MHz are often noncorrelated, which indicates that the propagation is governed by different mechanisms. The conclusion is drawn that, with regard to propagation forecasting, it is of special importance not only to predict the occurrence of elevated layers but also their effects at different frequencies. Author

**N71-21430#** Stanford Univ., Calif.

**TROPOSPHERIC INFLUENCE UPON DIFFRACTION PATHS**  
A. T. Waterman, Jr. In: AGARD Tropospheric Radio Wave Propagation, Pt. 1, Feb. 1971, 6 p. refs. (See N71-21409 10-07)  
Avail. NTIS

Two characteristics of diffraction paths are emphasized as criteria for distinguishing them from other propagation paths: the presence of a physical obstacle obstructing the line of sight between transmitter and receiver and the relatively slow fluctuation rate evident in the received signal. The troposphere affects signal characteristics in a variety of ways, not all of which are distinct and separable. Tropospheric scatter is a competing effect when conditions are right for it to predominate; the primary result is a marked increase in fading rate. Strongly refracting vertical gradients of refractive index effectively change the geometry of the path, making the apparent obstacle height greater or less and shifting the regions illuminated by narrow beam antennas. Phase perturbations at the diffracting aperture influence the correlation between spaced antennas and thus the optimum spacing for diversity reception. Author

**N71-21431#** Forschungsinstitut fuer Hochfrequenzphysik, Bonn (West Germany)

**VHF PROPAGATION MEASUREMENTS ON MIXED DIFFRACTION-SCATTER PATHS**  
R. Menzel and Kh. Rosenbach. In: AGARD Tropospheric Radio Wave Propagation, Pt. 1, Feb. 1971, 10 p. refs. Sponsored by Min. of Defence, Federal Rep. of Ger. (See N71-21409 10-07)  
Avail. NTIS

Variations of diffraction link characteristics are analyzed with respect to changes in relative effects of diffraction and scatter components and due to variable meteorological conditions. A basic signal analysis is undertaken and it is shown that the expected received signal consists of three components: a diffraction, a scatter and a reflection component. Experimental data discussed deal with two main points: (1) an explanation of the variations of the average received basic signal level of this link, and (2) an interpretation of occasionally occurring fading. The variations of the average received basic level of this mixed link correlate very closely with the variations of the ground temperature. A seasonal and diurnal effect was observed. A good correlation was found between fading periods, the presence of upper or lower inversion layers, and special wind characteristics as defined by direction and velocity. Author

**N71-21432#** Saarland Univ., Saarbrücken (West Germany), Inst. for Applied Physics and Electrotechnology

**METHOD OF CALCULATING PROPAGATION OF ELECTROMAGNETIC WAVES IN AN INHOMOGENEOUS ATMOSPHERE ABOVE ROUGH GROUND**  
Klaus-Dieter Becker. In: AGARD Tropospheric Radio Wave Propagation, Pt. 1, Feb. 1971, 10 p. (See N71-21409 10-07)  
Avail. NTIS

It is shown that the perturbation method for calculating the influence of roughness of the earth on the propagation of electromagnetic waves is also applicable in the case of an inhomogeneous atmosphere. The method itself is described in two steps. The solutions of Maxwell's equations for an inhomogeneous atmosphere are found by a method which reduces the problem to the solution of two modified wave equations. These can be formally

solved by the two-sided two dimensional Fourier transform. The transition conditions on the rough surface of the earth are fulfilled by making a Taylor's expansion for the total field in the rough surface and by taking in account the perturbation formulation for the total electromagnetic field. The new transition conditions and the radiation condition of Sommerfeld and Muller lead to a system of integral equations for the reflection and transmission coefficients of the disturbed electromagnetic field. Author

**N71-21433#** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France), Dept. EST/EFT

**INTERMODULATION AND FADING DURATION DUE TO PROPAGATION (LONG WIDEBAND COMMUNICATION) (INTERMODULATION ET DUREE DES EVANOUISSEMENTS DUS A LA PROPAGATION (LIAISON LONGUE ET A LARGE BANDE))**  
G. H. Lefrançois. In: AGARD Tropospheric Radio Wave Propagation, Pt. 1, Feb. 1971, 17 p. ref. In FRENCH (See N71-21409 10-07)  
(ONET NT EST APH 1) Avail. NTIS

The intermodulation noise during propagation of a combination helixian beam at 6 GHz and a wideband (32 MHz) is evaluated statistically for duration and depth of fading in order to clarify the effects of these phenomena in radio and numerical modulation. Obtained measurements show that intermodulation noise at median power becomes negligible before one minute because of the developing thermal noise as soon as fading passes beyond 10 db, therefore the noise is not detected during qualitative analysis of the combined propagation. Duration of fading follows the normal logarithmic quadratic law independent of depth. Transl. by G.G.

**N71-23451#** Advisory Group for Aerospace Research and Development, Paris (France)

**TROPOSPHERIC RADIO WAVE PROPAGATION, PART 2**  
Feb. 1971, 366 p. refs. Conf. held at Duesseldorf, 31 Aug. - 4 Sep. 1970. Mostly in ENGLISH, partly in FRENCH (AGARD CP-70-71) Avail. NTIS HC\$6.00/MF\$0.95

The effects of tropospheric medium characteristics on radio transmission are reported. Parameters of tropospheric scatter propagation, and tropospheric propagation predictions are considered. For individual titles see N71-23452 through N71-23474.

**N71-23452#** Rome Univ. (Italy), Electronics Inst.  
**PROPAGATION EFFECTS OF A VARIABLE SCATTER MECHANISM**

Giovanni d'Auria. In: AGARD Tropospheric Radio Wave Propagation, Part 1, Feb. 1971, 18 p. refs. (See N71-23451 12-07)  
Avail. NTIS HC\$6.00/MF\$0.95

The scattering of electromagnetic waves determined by the refractive index irregularities of the troposphere is reviewed, bearing in mind its effects in radio propagation. The mathematical formulation of the problem is briefly recalled both for reference purposes and in order to emphasize the meaning of the hypotheses generally assumed. Particular attention in this survey is given to experimental researches contributing to a better understanding of the tropospheric scatter mechanism. Author

**N71-23453#** Stanford Univ., Calif., Electronics Labs.  
**ANGLE AND DOPPLER MEASUREMENTS OF THE SPECULAR AND SCATTERED COMPONENTS OF TRANSHORIZON MICROWAVE SIGNALS**

Nicholas Cianos and Alan T. Waterman, Jr. In: AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 13 p. refs. (See N71-23451 12-07)  
(Contract DAAB07-70-C-0138)  
Avail. NTIS HC\$6.00/MF\$0.95

A summary and interpretation of transhorizon propagation experiments at 3.2 GHz over a 164 km (102 mile) path using a modified vertical 12 element data gathering array and receiving



system is presented. The measured amplitude and phase data recorded by the antenna array are processed to obtain the array angular response patterns, and the signal amplitude distributions and Doppler spectra. The radio data are supplemented with refractivity and temperature profiles. The occasions when strong layers are present are revealed not only by the meteorological profiles but also by the transhorizon signal. Author

**N71-23454#** Air Force Cambridge Research Labs., Bedford, Mass.  
**COMPARISON OF TURBULENT LAYER MODELS AND HIGH RESOLUTION FORWARD SCATTER RESULTS**

Uwe H. W. Lammers and John W. B. Day (Commun. Res. Centre) *In* AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 9 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

The theoretical resolution of a long range, scanning forward-scatter system has been studied, assuming narrow layers of homogeneously turbulent refractivity for the tropospheric height range from 5 to 15 km. Tropospheric composition, as determined experimentally through high resolution mapping techniques within the same regime, is analyzed for its spatial and temporal significance. The results indicate that a horizontal orientation frequently exists in the upper tropospheric structure. However, this is not the general case. Based on the common volume resolution and the range of the troposphere monitored, layers have been found to extend from 20 to 100 km and in rare cases up to 200 km with vertical widths from the resolution limit (0.7 km) to several kilometers. On the average, the turbulent homogeneity of the scattering medium is spatially and temporally quite limited, particularly in the vertical direction. Author

**N71-23455#** Hamburg Univ. (West Germany), Inst. for Radiometeorology

**OBSERVATIONS WITH SYNCHRONOUSLY OFFSET BEAMS ON A 77 km PATH AT 1.8 AND 4.4 cm**

H. D. Seehars *In* AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 10 p (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

Radio experiments on transhorizon links due to variations of the wavenumber vectors or displacements of the constant wavenumber vectors in space indicate the variations of the wavenumber spectrum. Results of these experiments on 1.8 and 4.4 cm wavelengths point to shapes of refractive index wavenumber spectra that show a strongly marked variance, but indicate a median value close to 11.3 corresponding to the theory of Megaw-Obukhov. The test of the homogeneity leads to an increase of the vertical and horizontal inhomogeneity with decreasing wavelength. Experiments on 4.4 cm point to a vertical inhomogeneity of about 1 db/100 m. Isotropy tests applied have demonstrated that there exists a weak anisotropy of turbulence which is not dependent on the frequency. Author

**N71-23456#** Imperial Coll. of Science and Technology, London (England)

**A STUDY OF THE EFFECTS OF TROPOSPHERIC AIR MASS MOVEMENTS ON THE FADING CHARACTERISTICS OF UHF TRANSMISSION BY THE USE OF A LABORATORY MODEL**

W. G. Burrows *In* AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 16 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

Various types of fading characteristics, obtained from a non-optical UHF link, are simulated in a simple laboratory model. The fading characteristics obtained from both the real full scale system and the model are described, for the purpose of comparison, by their power spectra. Results are given to show that, by comparing the air mass movements created in the laboratory model to produce a particular type of fading and those which might exist for the particular meteorological conditions under which similar fading

characteristics were obtained for the real full scale system, surface wind velocity is a significant parameter. This result, together with the unusual observations of air mass movements in the model, suggests that near surface circulatory air mass movement along a tropospheric path can give rise to significant distortion to the shape of the transmitter beam. This leads to the conclusion that transhorizon propagation in the tropospheric medium may be attributed to the effective divergence of a beam due to air mass lenses distributed along a given path. Author

**N71-23457#** Federal German Post Office, Darmstadt (West Germany), Research Inst.

**METHODS OF DISTINGUISHING SCATTER AND PARTIAL REFLECTION AT TROPOSPHERIC TRANSHORIZON PATHS**

L. Fehlihaber *In* AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 14 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

Two distinct theories of tropospheric transhorizon propagation have been set up during the past years. Scattering by random refractivity fluctuations and partial reflection from layer-like structures. More recent investigations showed that both mechanisms exist simultaneously with varying share and that this share depends on frequency, distance, altitude of the layer and on the state of the troposphere. In order to investigate the problem of the sharing of the two mechanisms, a simplified model of partial reflection has been derived, taking into account known tropospheric parameters. This model has been worked out numerically, and it has been found to agree well with empirical data. From the results it can be inferred that partial reflection from finite patches of steep refractivity gradients prevails with frequencies up to 200 MHz. With the higher frequencies scattering seems to predominate at all path lengths except the very short ones. Author

**N71-23458#** Federal German Post Office, Darmstadt (West Germany), Research Inst.

**OBSERVATIONS ON A 12 GHz SCATTER LINK OVER A 210 km PATH**

N. Abel *In* AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 9 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

Knowledge on transhorizon propagation at frequencies above 10 GHz is important in radiocommunications whenever transhorizon links are used or problems of interference between different radio systems must be solved. Some first results from about one year of observations on a 12 GHz link over a 210 km path are presented. In certain cases, signal types attributed to tropospheric scatter, partial reflections, or attenuation and scattering by precipitation are distinguished, although the exact share of these propagation effects was not yet determined. Tropospheric scatter by far prevails and thus determines the mean transmission loss relative to free space, which was found to agree well with predicted values and seems to be some decibels smaller than at 2 GHz on a similar link. A correlation exists between transmission loss and atmospheric temperature near the scattering volume. Author

**N71-23459#** Marconi Co. Ltd., Great Baddow (England), Research Labs.

**ANGLE DIVERSITY APPLIED TO TROPOSPHERIC SCATTER SYSTEMS**

M. W. Gough *In* AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 16 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

The generation of substantially independent signal paths over a tropospheric scatter link by directing two or more narrow beams at different scattering regions in the troposphere makes an attractive alternative to space diversity. The above factors are discussed and evaluated with the aid of a published theoretical treatment of tropospheric scattering which is well supported by experiment, and careful consideration is given to the influence of

atmospheric layering. It is shown how the aggregated losses enumerated above may be minimized for a specified angle diversity system by correct choice of horn feed dimensions in relation to a conventional paraboloid reflector. Various two way angle diversity systems involving quadruple and six fold diversity are evaluated and their optimized performances are compared with that of a conventional space frequency quadruple diversity system using four antennas per link of like size. Author

**N71-23460#** Saarland Univ., Saarbrücken (West Germany). Inst. for Applied Physics and Electronics

**DEPOLARIZATION OF DIPOLE RADIATION IN A MEDIUM WITH A STATISTICALLY HOMOGENEOUS AND ISOTROPIC DISTRIBUTION OF DIELECTRIC CONSTANT**

W. Mohr. In AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 10 p. refs. (See N71-23451 12-07)

Avail. NTIS HC\$6.00 MF\$0.95

The solutions of the vector wave equation with a Hertzian dipole as source term are considered in a medium with statistically homogeneously and isotropically fluctuating permittivity. For the two limits, wavelength much greater or much smaller than the correlation length of the fluctuations, the autocorrelation function of the depolarized part of the field is calculated by approximation methods. The limit of small wavelength is treated by the perturbation method; in the limit of great wavelength a renormalized dyadic Green's function is used to calculate the first term of the staircase approximation for the Bethe-Salpeter equation. The physical aspects of the formulas are discussed. Author

**N71-23461#** Saarland Univ., Saarbrücken (West Germany). Inst. for Applied Physics and Electronics

**EFFECT OF VEGETATION UPON ANTENNA PATTERN WITH SCATTER PROPAGATION ON UHF**

R. Zapp. In AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 7 p. refs. (See N71-23451 12-07)

Avail. NTIS HC\$6.00 MF\$0.95

The pattern of an antenna radiating with a small elevation angle as used in scatter propagation is disturbed by scattering of the field at the vegetation of the antenna's foreground. The vegetation can be regarded as a configuration of randomly distributed scatterers with random scattering properties. The irregular motion of the vegetation caused by wind leads to similar fading and depolarization of the transmitted field as known from tropospheric scatter propagation. The scatterers are described by their dielectric constants. Using the perturbation expansion series are derived for the average value of the field. The formalism regards the scattered field as a superposition of all the fields scattered from each scatterer of a fixed configuration. The concept of randomness requires averages to be taken over a statistical ensemble of scatterer configurations. Their multidimensional probability distribution is re-expressed in terms of the one-scatterer distributions so as to take account of coherent scattering. Author

**N71-23462#** Michigan State Univ., East Lansing  
**CONTROLLABILITY AND SOLVABILITY OF THE WAVE PROPAGATION IN TROPOSPHERE**

M. Z. v. Kazywoborin. In AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 12 p. refs. (See N71-23451 12-07)

Avail. NTIS HC\$6.00 MF\$0.95

The fundamental concepts of the theory of optimization and controllability are reviewed and applied to the system of fluid equations of the wave propagation in the troposphere. Then follows a brief review of other methods and a discussion on the refractive index, its methods of calculation and tests. Controllability in the troposcatter propagation closes the study. Author

**N71-23463#** Signatron Inc., Lexington, Mass.

**SIGNAL DISTORTION AND INTERMODULATION WITH TROPOSPHERIC SCATTER**

P. A. Bello, L. Ehrman, and P. Alexander. In AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 18 p. refs. (See N71-23451 12-07)

Avail. NTIS HC\$6.00 MF\$0.95

Multipath models used in the past for predicting the signal distorting properties of troposcatter links are reviewed. The fundamental importance of the delay power spectrum in predicting signal distortion is developed in some detail. Suggestions are given for improving multipath modeling by including beam bending and scintillation. The concept of beam broadening as producing increased multipath is shown to be erroneous. Some attention is given to relationships between multipath spread and path loss. Author

**N71-23464#** Florida Univ., Port Canaveral

**FREQUENCY CORRELATION FUNCTION FOR TROPOSCATTER CIRCUITS**

A. M. Manders. In AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 17 p. refs. (See N71-23451 12-07)

Avail. NTIS HC\$6.00 MF\$0.95

A mathematical model for the frequency correlation function of a tropospheric scatter channel is presented. The model uses atmospheric conditions and channel parameters as inputs. The results are presented in a form that allows estimation of the frequency correlation function under stable and unstable tropospheric conditions. Author

**N71-23465#** Martin Marietta Corp., Orlando, Fla.  
Communications and Electronics Div.

**CORRELATION BANDWIDTH MEASUREMENTS OVER TROPOSCATTER PATHS**

Richard A. Branham. In AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 21 p. refs. (See N71-23451 12-07)

(Contract DAAB07-69-C-0251)

Avail. NTIS HC\$6.00 MF\$0.95

Propagation measurements were made over four troposcatter paths. Simultaneous measurements of cross correlation coefficient versus frequency from zero to 9 MHz were obtained at 4.62 and 7.6 GHz in increments of 1 MHz. The paths were operated cyclically for two to five week periods to obtain the effects of season, terrain, weather, and time of day. Special tests covering 200 kHz frequency increments up to 800 kHz were also made. The signal strengths were recorded on magnetic tape and related in a digital computer to path cross correlation versus frequency, and distributions of fade duration, rates, signal amplitudes and fade depths. Emphasis is primarily placed on the cross correlation measurements. Author

**N71-23466#** Bell Telephone Labs., Inc., Holmdel, N.J.

**CHARACTERIZATION OF TROPOSPHERIC SCATTER CHANNELS BY IMPULSE RESPONSE MEASUREMENT**

G. C. Bailey. In AGARD Tropospheric Radio Wave Propagation, Part 2, Feb. 1971, 12 p. refs. (See N71-23451 12-07)

Avail. NTIS HC\$6.00 MF\$0.95

A new experimental program for evaluating the transmission capabilities of the tropospheric scatter medium is reported. A correlation type impulse response measurement system and a recently completed tropospheric scatter radio test link are described. Results of evaluation tests of the impulse response measurement system are presented in order to indicate its measurement capabilities and the type of information which can be obtained from it. Examples of experiments conducted by the troposcatter simulator and results from these experiments are given. Author

**N71-23467#** Forschungsinstitut für Hochfrequenzphysik, Bonn (West Germany)

**CALCULATING TROPOSCATTER INTERCHANNEL**

**DISTORTION USING A MONTE CARLO METHOD**

A. Wasiljeff / In AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 10 p refs (See N71-23451 12-07) (Contract T-01012)

Avail NTIS HC\$6 00/MF\$0 95

Multichannel signals are simulated by sets of randomly phased sinusoids uniformly spaced in frequency. The amplitudes of the sinusoids are set according to the prescribed preemphasis characteristic, some of them are set to zero to form the idle channels. The signal is transformed into the time domain with the aid of fast Fourier synthesis. This time signal is the modulation function for the transmitted electromagnetic field. The field which reaches the receiver after having been scattered by a tropospheric volume is described with the help of an integral including the spatial Fourier transform of the autocorrelation function of the dielectric constant in the tropospheric scatter volume. Analytical performance of demodulation of the calculated field in the receiver yields the distorted time function. Again the fast Fourier transform is used to analyze this function. The power density in the channels which had been originally idle is a measure of interchannel distortion. The process is repeated with a sequence of random noise samples from each sample with a set of independent random phases. The distortion is averaged to obtain the desired solution. The results of the Monte Carlo method approach those obtained by measurements with Gaussian noise. Author

**N71-23468#** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

**PROPAGATION BY ATMOSPHERIC HETEROGENEITIES AND FORECAST OF ATTENUATION (PROPAGATION PAR LES HETEROGENEITES DE L'ATMOSPHERE ET PREVISION DES AFFAIBLISSEMENTS)**

J. Barthelemy and L. Boithias / In AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 15 p refs. In FRENCH (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

A formula for calculating radio attenuation fluctuation as function of distance during propagation in a homogeneous atmospheric layer is developed that uses primary index gradients of the transmitting volume for calculating the receiving level. Considered are (1) starting angle effects as determined by angular and geographical distances, (2) intercommunication altitude effects, (3) antenna gain loss characteristics, (4) distance, climate and starting angle effects on antenna gain loss, (5) a limiting law for gain loss in high resolution antennas, and (6) effects of antenna gain characteristics, distance and starting angles on transmissible bandwidth. Transl by G G

**N71-23469#** AEG Telefunken, Beckring (West Germany) Dept. of Radio Link Systems

**PROPAGATION CHARACTERISTICS OF TROPOSPHERIC SCATTER RADIO LINKS IN THE 5 GHz RANGE WITH RESPECT TO PATH LOSS PREDICTIONS**

Klaus Radermacher and Guenther Rappallier / In AGARD Troposphere Radio Wave Propagation, Part 2 Feb 1971 10 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

Planning of stationary and use of mobile tropospheric scatter systems require prediction methods of tropospheric scatter losses for links in air, climate. Prediction methods are considered as to their application and compared to the current state of knowledge in the field of tropospheric scatter propagation. Test results obtained by field testing a new mobile tropospheric scatter system, operating in the band about 4.5 GHz on four paths are compared with predictions. The test results were apparently, at times, adversely affected by anomalous weather conditions. Frequency saving operation with quadruple space diversity using two polarizations is possible. Author

**N71-23470#** Forschungsinstitut fuer Hochfrequenzphysik, Werthhoven (West Germany)

**DAILY AND HOURLY FORECAST OF TROPOSPHERIC PROPAGATION PARAMETERS**

H. J. Albrecht / In AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 12 p refs. Supported by Min. of Defence, W. Germany (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

The present state of the art of daily and hourly forecasts of tropospheric propagation parameters, on the basis of research work known at this juncture is summarized in accordance with the subject matter, frequent reference is made to meteorological conditions and their predictions. Following analyses on propagation aspects and their predictability, meteorological aspects as well as the predictability for specified telecommunication links are considered. Author

**N71-23471#** Forschungsinstitut fuer Hochfrequenzphysik, Werthhoven (West Germany)

**SHORT TERM FORECAST OF SIGNAL BEHAVIOUR WITH TROPOSPHERIC SCATTER LINKS**

D. E. Marquardt / In AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 49 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

Forecasts of signal attenuation with tropospheric scatter links by means of meteorological values have shown that considerable increases of signal attenuation correlate with the passage of cold fronts through the scatter volume and that the intensity of this signal decrease is related to the age of the front. Considered is the present state of research work with particular attention on the interpretation of correlation results, a detailed comparison between predicted and observed signal behavior is presented. In addition, signal enhancements and their possible forecasts on the basis of the occurrence probability of super-refraction layers is dealt with. Other parameters determining general signal behavior are also treated. Author

**N71-23472#** Institute for Telecommunication Sciences, Boulder, Colo

**PREDICTION OF TROPOSPHERIC RADIO TRANSMISSION LOSS OVER IRREGULAR TERRAIN**

A. G. Longley and P. L. Rice / In AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 8 p refs (See N71-23451 12-07)

Avail NTIS HC\$6 00/MF\$0 95

A method for calculating long term median radio transmission loss over irregular terrain at frequencies above 20 MHz is described. The model is particularly useful for area predictions of transmission loss as a function of distance, frequency, antenna heights, and terrain characteristics where individual path profiles are not known. Such predictions are needed for military communication and surveillance, for land mobile, broadcasting, and air-to-ground systems, and for calculating preliminary performance estimates for system design. The prediction model summarizes much of our present knowledge of tropospheric propagation theory and has been tested against measurements over a wide range of distances, for frequencies from 20 to 10 000 MHz, for terrain types ranging from smooth plains to rugged mountains, and with antenna heights ranging from very low to aircraft heights. Author

**N71-23473#** Lockheed Electronics Co., West Long Branch, N.J.  
**STATISTICAL PROPAGATION MODEL FOR IRREGULAR TERRAIN PATHS BETWEEN TRANSPORTABLE AND MOBILE ANTENNAS**

J. P. Murphy / In AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 21 p refs (See N71-23451 12-07) (Contract DAAB07-67-C-0104)

Avail NTIS HC\$6 00/MF\$0 95

A statistical model of tropospheric radio propagation loss that can be used by ground mobile radio communications systems

designers without the aid of a computer program is developed. Such a model provides a first order estimate of median values and standard deviation values of basic transmission loss for path over a particular type of terrain based on the assumption that path-to-path variability of basic transmission loss is close to that of a normal distribution in decibels. The method used to develop the model is closely related to the one used to develop the Egli model for radio propagation above 40 MHz over irregular terrain. The data used to develop the model have been measured on paths between antennas that are transportable and antennas that are mobile. The only independent parameters used are signal frequency, antenna heights and path distance.

Author

**N71-23474#** Hamburg Univ (West Germany) Meteorological Inst

#### THE STATE OF RADAR RANGE PREDICTION OVER SEA

H Jaske. In AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 11 p refs (See N71-23451 12-07)

Avail NTIS HC \$6.00/MF \$0.95

The methods of radar range prediction of marine cm radars are closely related to the boundary layer theory for the propagation conditions are governed by the low level evaporation duct in 85% of time. Over a wide range of atmospheric stability the logarithmic profile with a stability-dependent profile coefficient yields a good correlation between radio field strength and duct thickness. For strong deviations from the neutral equilibrium however more complicated profile forms are employed.

Author

**N72-16085#** Advisory Group for Aerospace Research and Development, Paris (France)

#### PROPAGATION LIMITATIONS IN REMOTE SENSING

John B. Lomax, ed. (Stanford Res Inst, Menlo Park, Calif.) Oct 1971 424 p refs. Presented at the 17th Symp. of the Electromagnetic Wave Propagation Panel of AGARD Colorado Springs, Colo 21-25 Jun 1971. Original Contains Color Illustrations.

(AGARD CP-90 71) Avail NTIS HC \$6.00/MF \$0.95

Theoretical and experimental performance analyses are reported for various remote sensing systems in order to develop their propagation ranges and suitability in relation to investigated media. Results cover the spectrum from optical to radio frequencies. For individual titles, see N72-16086 through N72-16119.

**N72-16086#** Army Engineer Topographic Labs, Fort Belvoir Va

#### A PROGRAM FOR THE DEVELOPMENT OF ADVANCED CAPABILITIES FOR COLLECTION, ANALYSIS, PRODUCTION AND DISSEMINATION OF MILITARY GEOGRAPHIC INTELLIGENCE

Kenneth R. Kothe. In AGARD Propagation Limitations in Remote Sensing Oct 1971 36 p (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

The objectives of the R&D program are identified as collection systems, data reduction systems and information systems. To improve data collection capabilities, work is described associated with sidelooking airborne radar and color multiband photographic systems. To improve the data reduction, research and development leading to automated image data extraction capability is reviewed. Then the development of a military geographic information system with an example output is outlined in relation to an overall concept. In conclusion, it appears the research and development objectives can be attained to implement the concept of operations in the 1985 time frame.

Author

**N72-16087#** Army Engineer Topographic Labs, Fort Belvoir Va

#### PROJECT SAND REMOTE SENSING FOR ENGINEER CONSTRUCTION MATERIALS

Donald G. Orr and James R. Quick. In AGARD Propagation Limitations in Remote Sensing Oct 1971 17 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

Remote sensor flights have been conducted over areas in the Mississippi Delta to determine the sensor configuration, analysis techniques, and diagnostic criteria for locating engineer construction materials under Project Sand. The sensor utilized included photography, thermal infrared, and sidelooking radar. In addition to the aerial imagery acquisition, ground measurements were made in each of the areas under investigation. The sensor imagery and ground truth data were analyzed by a team of experts in various earth science disciplines. The airborne operations and field data collection are described and a summary of the analysis results with unclassified illustrations are presented.

Author

**N72-16088#** Development and Resources Transportation Co., Silver Spring, Md

#### AUTOMATIC PROCESSING OF ARCTIC PACK ICE DATA OBTAINED BY MEANS OF SUBMARINE SONAR AND OTHER REMOTE SENSING TECHNIQUES

Leonard A. LeSchack, William D. Hibler, III (Army Cold Res Res and Eng Lab, Hanover, N. H.), and Frederick H. Morse (Maryland Univ, College Park). In AGARD Propagation Limitations in Remote Sensing Oct 1971 19 p refs. Original Contains Color Illustrations (See N72-16085 07-07)

(Contract N00014-70-C-0110 NR Proj 307-322)

Avail NTIS HC \$6.00/MF \$0.95

Three remote sensors have been used for examining the upper and under surface of the Arctic ice pack: an upward looking sonar mounted on a nuclear submarine transiting beneath the ice producing an under ice profile; a vertically mounted airborne laser producing an upper ice surface profile; and an airborne infrared scanner in the 8-14 micron range producing a heat picture of the ice surface. The sonar data were digitized and analyzed. Frequency distribution of amplitudes of the profile data indicates that young ice has a sharp, uni-modal distribution, older, more jumbled ice has a broad based uni-modal distribution and old, much ridged ice has a bi-modal distribution. The same analytical techniques were used to process airborne laser profile data of pack ice. Analysis of profiles of multi-year ice and young ice show that the young ice has greater amplitude of all ridge spacings shorter than 20 m than does the multi-year ice. Airborne infrared scanning imagery of pack ice was color contoured using a spatial data system. A simplified energy balance equation was used as a method to determine thickness of ice scanned.

Author

**N72-16089#** Communications Research Centre, Ottawa (Ontario)

#### THEORY AND FIELD TESTS OF A MICROWAVE RADIOMETER FOR DETERMINING SEA ICE THICKNESSES

A. W. Adey. In AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

A theoretical analysis of UHF emissions from sea ice and ocean water is outlined. A radiometer system designed to observe these emissions operating at frequencies from 400 MHz to 1.1 GHz has been designed and built. The results of initial ground based and airborne tests of this instrument are presented. Initial results tend to confirm the theoretical analysis and predictions.

Author

**N72-16090#** Kansas Univ, Lawrence. Remote Sensing Lab

#### RADAR IMAGING APPLICATIONS PAST, PRESENT, AND FUTURE

Richard K. Moore. In AGARD Propagation Limitations in Remote Sensing Oct 1971 19 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

Some of the proven applications of radar are outlined and future applications are suggested. Although restricted mostly to imaging systems, brief mention is made of the application of

non-imaging radars to determining wind speeds over the oceans. Applications to be include geology, geography, hydrology, bio-geography (including agriculture), oceanography, and cartography. Author

**N72-16081#** Louisiana State Univ., Baton Rouge. Dept. of Geography and Anthropology.  
**CUMULATIVE FREQUENCY CURVES OF THE DARIEN PROVINCE, PANAMA**

Anthony J. Lewis and William Waite (Arkansas Univ.) In AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

Histograms and cumulative frequency curves of terrain slope are important in the quantitative description of geomorphic regions and aid in the study of land utilization and terrain mobility. Recently a method for obtaining such terrain slope information from radar imagery was developed utilizing the necessary relationship between terrain slope and the depression angle for the occurrence of radar shadows and the variation in depression angle from near to far range across the radar image. The characteristic shape of the cumulative frequency curves for four general geomorphic regions in Panama—plains, low hills, high hills, and mountains—proved diagnostic and substantiated both the qualitative geomorphic boundaries and the quantitative slope data determined from radar imagery. Only quantitative regional slope information is available for the poorly mapped Darien area in Panama. Author

**N72-16082#** Kansas Univ., Lawrence. Dept. of Geography.  
**VEGETATION MAPPING WITH SIDE LOOKING AIRBORNE RADAR, YELLOWSTONE NATIONAL PARK**

Norman E. Hardy, Jerry C. Ginner, and William O. Lockman. In AGARD Propagation Limitations in Remote Sensing Oct 1971 19 p refs (See N72-16085 07-07)

(Contract NAS9 10261)

(NASA-CR 125451) Avail NTIS HC \$6.00/MF \$0.95 CSCL 08B

The purpose of this study is to delimit the vegetation communities of Yellowstone National Park to the greatest extent possible by interpreting SLAR imagery and to identify factors which could be modified or controlled to enhance information content for any future SLAR vegetation mapping projects. The interpretation approach to the SLAR imagery was first to define the boundaries of the vegetation communities. After boundary definition a classification of vegetation types was established based upon elevations, moisture and slope features evident in the SLAR image. To assist in the classification of the vegetation communities a matrix interpretation key was constructed. Comparison of the vegetation map developed from SLAR and that prepared from ground truth data points to the ability of an active microwave image to provide vegetation information at the community level. Author

**N72-16083#** Physics Lab, RVO TNO, The Hague (Netherlands).  
**THE RADAR BACKSCATTER OF VEGETATION**

G. P. deLoor and A. A. Jurneens. In AGARD Propagation Limitations in Remote Sensing Oct 1971 7 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

To study the possible use of image tone in SLAR imagery for inventory purposes, a series of measurements were performed at X band (and some at Ka band) on the backscatter coefficients of single fields in an agricultural area through a complete growing season. Use was made of a stable platform with the radar at an altitude of 75 m above the terrain. The influence of the weather on the backscatter coefficient is studied by comparing the measurements with the output of an automatic weather station. Author

**N72-16084#** Naval Research Lab., Washington, D.C. Hulburt (E.O.) Center for Space Research.  
**WAVE HEIGHT MEASUREMENTS WITH A NANOSECOND RADAR**

B. S. Yaplee, A. Shapiro, D. L. Hammond, and E. A. Uliana. In AGARD Propagation Limitations in Remote Sensing Oct 1971 13 p ref (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

A radar system has been developed with a sufficiently narrow pulse width to resolve the vertical wave structure of ocean waves. The radar illuminates a 70 cm diameter spot on the ocean at normal incidence and three wave poles are placed in a delta configuration around the spot for ground truth measurements. A corner reflector is placed at the center of the antenna beam to calibrate radar measurements both in range and amplitude. Wind conditions are monitored using the tower's anemometer. These ground truths are then used in relating the radar measurements to actual sea conditions. The wave heights encountered range from two to six feet. Results of the radar measurements are presented and compared with simultaneous wave pole measurements of the sea surface structure. Author

**N72-16085#** Naval Research Lab., Washington, D.C.  
**REMOTE PASSIVE MICROWAVE MEASUREMENTS OF THE SEA SURFACE**

James P. Hollinger. In AGARD Propagation Limitations in Remote Sensing Oct 1971 7 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

The important potential of all weather determination of ocean surface wind fields by means of remote passive microwave sensing is discussed. The wind speed dependence of the microwave brightness temperature of the sea is interpreted as resulting primarily from small scale wave structure at wind speeds below about 15 to 20 m/sec and from the increasing coverage of sea foam at higher wind speeds. Measurements of these two effects are presented and the characteristics of each described separately. The two effects are combined to estimate the total microwave brightness temperature dependence of a wind driven sea as viewed from a satellite. Taken together the two effects allow the determination of ocean surface wind fields over the entire range of wind speeds. Author

**N72-16086#** Naval Research Lab., Washington, D.C.  
**REMOTE SENSING OF OCEAN EFFECTS WITH RADAR**

N. W. Gurnard. In AGARD Propagation Limitations in Remote Sensing Oct 1971 12 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

Remote sensing of ocean surface effects is reported with the objective of evolving theoretical models of these effects to aid systems design and the acquisition of data in situ and in laboratory simulations to determine appropriate parametric relationships. The four frequency radar system, a calibrated airborne measurement facility, has been extensively used for the in situ data collection. The radar is capable of operating sequentially on X band (9910 MHz), C band (4455 MHz), L band (1228 MHz) and P band/UHF (428 MHz) with both horizontal and vertical polarization. A review of the theoretical models and the parametric relationships is presented. In the course of the study two new techniques for remotely sensing wave spectra have been evolved and used to obtain an explanation for the wavelength dependence of the sea return in low wind fields. Author

**N72-16087#** Forschungsinstitut fuer Hochfrequenzphysik, Weithhoven (West Germany).  
**PROPAGATION EFFECTS ON MONITORING ATMOSPHERIC FINE STRUCTURE USING SIDE SCATTER ON APPROPRIATE FREQUENCIES**

H. J. Albrecht and M. Piening. In AGARD Propagation Limitations in Remote Sensing Oct 1971 7 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

The possibilities of extending side scatter analysis to higher frequencies are examined with regard to the very timely subject of monitoring air pollution above industrial areas, cities and other exposed areas. The limits of detecting appropriate element

sizes as well as the combination of such methods with turbulence analysis by side scatter are considered for the purpose of estimating the degree of danger and its variation.

Author

**N72 16098#** Fengler (C) Hamburg (West Germany)

# **REMOTE SENSING AND ATMOSPHERIC LAYERS**

C. Fengler. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 8 p. refs (See N72 16085 07 07). Avail NTIS HC \$6.00/MF \$0.95

Since absorption and scattering are well-known effects for the propagation limitations in remote sensing by electromagnetic waves refraction, reflection as well as ducting effected by atmospheric layers are considered. The reflection coefficient of Epstein profiles is treated in order to illustrate the effect of total reflection by grazing incidence. The deflection from a concentric layer of rays starting at the earth's surface and of rays coming from the outside of the earth is considered. The theoretical treatment is completed by presenting results of measurements of an earth-earth radio link as well as of a space-earth radio link evaluated under the aspect of the tropospheric layer structure.

Author

**N72 16099#** Wisconsin Univ. Middleton. Geophysical and Polar Research Center

# **ELECTROMAGNETIC SOUNDING OF ICE THICKNESS**

C. R. Bentley and J. W. Clough. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 7 p. refs (See N72 16085 07 07). Avail NTIS HC \$6.00/MF \$0.95

The efficiency of ice thickness determination in Antarctica and elsewhere has been vastly improved by the use of electromagnetic sounding. The electromagnetic sounder which is basically a low frequency radar system is easily adapted to use in an aircraft and is capable of measuring thicknesses of ice as great as 4 km. Since pure ice has an extremely low conductivity electromagnetic wave propagation at a frequency of around 35 MHz is essentially non-dispersive. Absorption takes place in close accordance with the high frequency tail of a Debye relaxation spectrum and is highly temperature dependent. The attenuation factor varying by 50-100 db/km over the range of temperatures (about 60 C) found in different glaciers. The attenuation in very cold ice is so small that it is substantially less than the normal spherical spreading loss. Losses occurring at the reflecting boundary are about 10-20 db for most earth materials but may be more if the boundary is rough. At a sharp ice-sea water boundary however the reflection loss is only 0.5 db.

Author

**N72 16100#** Army Engineer Topographic Labr. Fort Belvoir, Va.

# **A MATHEMATICAL ANALYSIS OF THE PROPAGATION AND REFLECTION OF PLANE ELECTROMAGNETIC WAVES IN A NONHOMOGENEOUS ISOTROPIC MEDIUM**

Richard A. Hevenor. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 9 p. refs (See N72 16085 07 07). Avail NTIS HC \$6.00/MF \$0.95

Understanding of the propagation of electromagnetic waves in natural terrain surfaces can be aided by solving the vector wave equation for the case when the conductivity, the dielectric constant and the magnetic permeability are functions of soil depth. The problem to be analyzed is that of a nonhomogeneous half space where the conductivity and dielectric constant are arbitrary functions of depth. The basic approach employed is that of the geometrical optics solution of the wave equation. The final results yield expressions for the magnitude and phase of an electromagnetic field propagating in the nonhomogeneous medium for horizontal and vertical polarizations.

Author

**N72 16101#** Naval Electronics Lab. Center for Command Control and Communications, San Diego, Calif.

# **REMOTE SENSING OF TROPOSPHERIC STRUCTURES USING HIGH RESOLUTION RADAR**

J. H. Richter, E. E. Gossard and D. R. Jensen. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 13 p. refs (See N72 16085 07 07). Avail NTIS HC \$6.00/MF \$0.95

A very sensitive ultra high resolution radar has been developed for the purpose of studying the refractive index structure of the troposphere. The radar is a ground based vertically pointing FM-CW radar with a range resolution of one meter. The radar and its performance characteristics are described. The radar routinely detects layer structures in the lower troposphere. These layers are always associated with gradients in the vertical refractive index profile and are frequently very thin, approaching the resolution of the radar. Very often they are perturbed by wave motions. Examples of various wave patterns are presented.

Author

**N72 16102#** Wisconsin Univ. Middleton. Geophysical and Polar Research Center

# **EFFECT OF BEAM WIDTH ON ACOUSTIC SIGNALS SCATTERED AT A ROUGH SURFACE**

C. S. Clay and G. A. Sandness. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 8 p. refs (See N72 16085 07 07). Avail NTIS HC \$6.00/MF \$0.95

Underwater acoustic experiments were made in a laboratory tank in which the signals were scattered at a wind-blown surface. The rms roughness and spatial correlation function of the surface were measured by wave height probes. The ratio of the mean rectified signal scattered at the rough surface and that reflected at the smooth surface was measured for vertical incidence. Even though the surface was rough the mean rectified signal was inversely proportional to the source distance plus receiver distance. At large roughness the reflection scattering function depends upon beam width and tends to the usual plane interface reflection function.

Author

**N72 16103#** National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

# **INFRARED AND MULTISPECTRAL REMOTE SENSING**

M. R. Holter. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 12 p. refs. Original Contains Color Illustrations (See N72 16085 07 07). (NASA TM X 67496). Avail NTIS HC \$6.00/MF \$0.95. CSCL 148

The history of infrared from its discovery in 1800 by Herschel is sketched. Recent advancements are described leading to modern infrared remote sensing devices. The performance of such devices is illustrated and future directions of development outlined. The recent extension of the infrared scanner to the multispectral sensing and pattern recognition system is described. Results from such systems are shown. Limitations in their utility due to lack of understanding of signatures are described and likely future developments are outlined.

Author

**N72 16104#** Electronique et de Physique Laboratoire d'Appliquees, Paris (France)

# **FUNDAMENTAL AND PRACTICAL LIMITS OF REMOTE INFRARED IMAGING INSTRUMENTS OPERATING BETWEEN 2.5 AND 18 MICRONS**

J. Desvignes. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 14 p. refs. In FRENCH, ENGLISH summary (See N72 16085 07 07). Avail NTIS HC \$6.00/MF \$0.95

Main advantages of infrared radiation for remote sensing are outlined and the relations between space time and signal level resolving power of the instruments are considered in the propagation effects of signal attenuation and stray radiation. An analysis of the hypothesis and results of a computation of overall atmospheric transmittance for instruments using various types of detectors are given. This computation takes into account the absorption and diffusion by gases and aerosols in horizontal propagation versus the distance.

Author

**N72-16106#** Lille Univ. (France) Lab d'Optique Atmospherique  
**ANALYSIS OF RADIOMETRIC INFRARED SEA TEMPERATURE MEASUREMENTS**

P. Y. Deschamps, P. Lecomte, and J. C. Vanhoulte. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 9 p refs. In FRENCH (See N72-16085 07-07)  
 Avail NTIS HC \$6 00/MF \$0 95

Correction procedures are described that provide real temperature data for a sea surface from infrared radiometric measurements. The primary error source is reflection of sky radiation from the surface; it is corrected by real measurements at sea level. The secondary error is caused by transmission through the air layer between the radiometer and the sea; it is corrected theoretically. Above described corrections provide absolute temperature values for the sea surface with an accuracy of about 0.1 degree. Transl by G G

**N72-16108#** Lille Univ. (France) Lab d'Optique Atmospherique  
**ANALYSIS OF RADIOMETRIC INFRARED MEASUREMENTS ON CLOUD TEMPERATURES AND STRUCTURES**

Y. Fouquart and J. Lencle. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 8 p refs. In FRENCH (See N72-16085 07-07)  
 Avail NTIS HC \$6 00/MF \$0 95

The angular distribution of radiation intensity in a cloudy atmosphere is studied by the 4.3 micron carbon absorption band. Evaluation of the observed spectral frequencies shows that radiation transmission depends on the optical thicknesses of cloud layers. Transl by G G

**N72-16107#** National Environmental Satellite Center, Washington, D.C.  
**FACTORS AFFECTING THE ACCURACY OF SEA SURFACE TEMPERATURE MEASUREMENTS FROM TIROS-SR DATA**

J. Leese, W. Pichel, B. Goddard, and R. Brower. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 13 p refs. (See N72-16085 07-07)  
 Avail NTIS HC \$6 00/MF \$0 95

The improved TIROS satellite sensor package contains a two channel scanning radiometer which operates in the 52- to 73-micron visible range and the 10.5- to 12.5-micron infrared water vapor window. One of the primary applications of the IR data is the operational determination of global sea surface temperatures. The objective is to make statistically integrated measurements, over areas approximately 100 km on a side, which agree with ground truth measurements within a root-mean-square deviation no larger than 1 C. A quantitative error analysis of the TIROS system, combined with tests on real data, shows that the objective should be reached using only IR data in regions where the magnitude of the temperature gradient is less than 2 C per 100 km. In regions where the temperature gradients are 2 to 4 C per 100 km the inclusion of SR data from the visible channel to reduce cloud contamination errors should place the accuracy objective within accessible limits. Author

**N72-16108#** Atmospheric Sciences Lab., White Sands Missile Range, N. Mex.  
**ERBIUM LASER PROPAGATION IN A CO2 ATMOSPHERE IN THE NEAR INFRARED**

Kenneth O. White, E. Howard Holt, Stuart A. Schleusener (New Mex. State Univ., Las Cruces), and Robert F. Calfee (NOAA, Boulder, Colo.). In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 5 p refs. (See N72-16085 07-07)  
 Avail NTIS HC \$6 00/MF \$0 95

The transmission of laser energy in a carbon dioxide atmosphere has been measured in the 1.54 micrometers spectral region. An erbium laser was used which had two output emission regions in the eye-safe realm of the spectrum. The CO2 sample was contained in a pressure and temperature controlled, 20 m. White cell. The monitor and transmitter laser pulses were detected by germanium photodiodes and recorded on a dual

parameter pulse-height analyzer which provided a real-time indication of the transmission and the quality of the data. A spectral scan over the laser output was obtained by sending a portion of the laser beam through a 33 m grating spectrometer which was preset to a narrow spectral region within one of the two output regions of the laser. The spectrometer was scanned over the laser output and the transmission obtained as a function of wavelength. Data and theoretical calculations are presented for a 480 m path length, a temperature of 30 C, and a CO2 pressure of one atmosphere. Author

**N72-16109#** Kansas Univ., Lawrence. Center for Research, Inc.  
**EFFECT OF ANGULAR VARIATION ON TERRAIN SPECTRAL REFLECTIVITY**

Dwight D. Egbert and Fawwaz T. Ulaby. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 10 p refs. (See N72-16085 07-07)  
 (Contract DAAK02-68-C-0089)  
 Avail NTIS HC \$6 00/MF \$0 95

A technique is described that determines the optimum filter combinations and the feasibility of multiband photography in the visible and near infrared regions in planning remote sensing missions. The test provides multispectral reflectivity curves not only for targets to be identified, but also for those backgrounds against which they are encountered. The procedure incorporates a method for determining spectral reflectance as a function of solar altitude, incidence look angle, and azimuth look angle. This angular dependence of reflectivity is significant and an aid in detecting certain targets. It was found that for one target-background pair (asphalt and grass) the contrast ratio ranges from 2.1 to 0.5.1 under different angle conditions. Author

**N72-16110#** Army Engineer Topographic Labs., Fort Belvoir, Va.  
**THE USE OF COLOR AERIAL PHOTOGRAPHY IN THE RECONNAISSANCE OF SOILS AND ROCKS**

Abraham Anson. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 10 p refs. (See N72-16085 07-07)  
 Avail NTIS HC \$6 00/MF \$0 95

A specialized interpretation of soils and rocks can be obtained from aerial photography in color. In using aerial color film, the three-layer emulsion presents a more readily understood spectral relationship than can be obtained from black-and-white film. The reconnaissance of inaccessible areas with their rock structures is more rapidly analyzed than solely by ground exploration. Geologists analyze soil conditions using 1:20,000 scale aerial color and infrared photographs together with sparse generalized ground information. Author

**N72-16111#** Kansas Univ., Lawrence. Dept. of Geography  
**AN ANALYSIS OF MULTISPECTRAL IMAGERY FOR TROPICAL LAND USE DISCRIMINATION**

Roland D. Mower. In AGARD Propagation Limitations in Remote Sensing. Oct 1971. 16 p refs. (See N72-16085 07-07)  
 (Contract DI 14 08-0001-12077)  
 Avail NTIS HC \$6 00/MF \$0 95

Imagery data from a number of flight lines over Puerto Rico were analyzed to determine to what extent selected land use classes could be discriminated using conventional image interpretation techniques. The results were then compared with those obtained through use of a semi-automated densitometer/computer process. The semi-automated technique was also employed to determine which of the nine imagery channels (Ektachrome blue, green, red, and IR, multiband blue, green, red, and IR, and IR scanner) provides the best discrimination for each of the land use classes considered. A number of tentative conclusions were made regarding the relative performance of the imagery channels tested. Author

**N72-16112#** TRW Systems Group, Redondo Beach, Calif.  
**SEA BRIGHTNESS TEMPERATURES AT MICROWAVE FREQUENCIES**

R. J. Wagner and P. J. Lynch. In AGARD Propagation Limitations in Remote Sensing Oct 1971 16 p refs (See N72-16085 07-07)

Avail NTIS HC \$8.00/MF \$0.95

A complete geometrical optics theory of rough-surface emission and scattering is developed which accounts explicitly for surface shadowing effects and the contributions of double-scattered radiation. The validity of the emission theory is tested by comparing the results with a case for which the exact solution is known. A theorem is proved which establishes, for the domain of geometrical optics, the existence of rigorous upper and lower bounds to the effects of surface roughness on brightness temperatures: the Peake representation yields the upper bound provided shadow corrections, at least, are included, while an alternative representation provides the lower bound. Microwave brightness temperatures for the sea are calculated for a cylindrical roughness model. Double scatter contributions are shown to be appreciable and, with their inclusion, accurate calculation of brightness temperatures is possible. A model for a wind-driven spray layer is integrated into the theory and semi-empirical corrections for foam added; the results agree well with rough-sea data. Author

N72-16113# Air Force Cambridge Research Labs., Bedford Mass

#### STATISTICAL METHODS OF INDIRECT PROBING OF THE ATMOSPHERE

V. J. Falcone, Jr. and K. Mano. In AGARD Propagation Limitations in Remote Sensing Oct 1971 5 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

Three statistical methods for inversion of the radiative transfer equation for any Fredholm integral equation of the first kind are examined. For the microwave region of the electromagnetic spectrum the unknown function to be determined under the integral of the radiative transfer equation is the atmospheric temperature. Westwater and Strand determine the temperature profile by applying linear estimation theory. Tikhonov on the other hand assumes a smoothing functional which is minimized by the Euler-Lagrange equation. These two methods are shown to be equivalent when appropriate identification of terms is made, and where the regularization term of the smoothing functional is a linear differential operator. This equivalence is shown by use of Bayes estimation which is equivalent to the linear estimation theory and in which the same functional form as the smoothing functional is minimized. Author

N72-16114# Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

#### IMAGE ANALYSIS BY MULTIPLEX CODING

Andre Girard. In AGARD Propagation Limitations in Remote Sensing Oct 1971 15 p refs. In FRENCH-ENGLISH summary (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

An incoherent radiation distribution is analyzed by means of a system whose radiation transducer is a flux detector receiving incoming signals in a coded form. The coding presents the characters of a multiplex method; it ensures the optimum use of the available time to analyze the distribution under study as the flux detector receives during the whole analysis time the radiation issued from all the elements of the space function. A gain in the signal/noise ratio is thus obtained as compared to direct analysis methods. The spectral range considered is in the infrared region. According to the first experimental results obtained the use of pseudo-random binary cyclic codes seems the best in view of the practical advantages they offer. Author

N72-16115# Max Planck Institut fur Aeronomie, Lindau-Uber-Norheim (West Germany)

#### AN APPLICATION OF THE MONTE CARLO METHOD TO REMOTE SENSING SYSTEMS

J. Roettger. In AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

The reliability of remote sensing systems, making use of electromagnetic wave propagation, is considerably influenced by propagation limitations due to the varying refractive index of the passed and sensed medium. Monte Carlo calculations, simulating an experiment by statistical computer mathematics, are carried out for ionospheric off-great-circle propagation on the transequatorial radio path Lindau-West Germany-Tsuneb-South West Africa. These calculations yield information about the error probability and reliability concerning the determination of sidereflection areas in the equatorial zone, using probability distributions of the parameters of ionospheric wave propagation. Statistical tests prove that the results, computed from remote measured data by means of a Monte Carlo technique, agree sufficiently well with direct measurements at the equator. Author

N72-16116# Michigan State Univ., East Lansing

#### TURBULENCE AND REFRACTIVITY CHANGES AND THEIR SENSING BASED UPON THE WAVE MECHANICS THEORY

M. Z. V. Krzywoblocki. In AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

Some methods of the quantum field theory in statistical physics are applied to a Bose type of medium fluid. The application of the wave mechanics theory to a spatial domain in a turbulent field is outlined and the propagation of waves in a turbulent medium is formulated by the Tatarski method. This is accompanied by a discussion of wave scattering in the turbulent atmosphere as well as of the influence of the turbulent field upon the magnitude and the variation of the refractive index for radio waves. Successful application of the concept of remote sensing to the status of atmospheric turbulence and refractivity variations is shown. Author

N72-16117# Kansas Univ., Lawrence, Center for Research, Inc.

#### ON BACKSCATTERING FROM TWO SCALE ROUGH SURFACES

A. K. Fung and H. L. Chan. In AGARD Propagation Limitations in Remote Sensing Oct 1971 13 p refs (See N72-16085 07-07)

(Contract NAS1-10048)

(NASA CR 125452) Avail NTIS HC \$6.00/MF \$0.95 CSCL 20N

The two scale composite rough surface model usually considered is one made up of large undulations over which small irregularities are superimposed. This general model may be further subdivided into two other models: (1) the large undulations are large in dimension than that of the illuminated area so that within the beam of illumination the picture is a tilted perturbed plane, and (2) the large undulations are of such a size that at least several undulations can be found within the beam. The first model is essentially the small perturbation model. The second model is much more complicated; the contribution from the small irregularities may be computed by summing powers from the large facets constituting the large undulations. The total contribution from the composite surface is then taken to be that from the large undulations plus that from the small irregularities averaged over the large undulations. If the non-coherent assumption is not made, the total scattered field from the illuminated area must be computed before evaluating the power. This is the approach adopted by this paper to calculate both the vertically and horizontally polarized scattering coefficients. Author

N72-16118# Wisconsin Univ., Madison, Dept. of Electrical Engineering

#### THE IDENTIFICATION OF INHOMOGENEOUS MEDIA FROM TRANSIENT DIFFUSION OF ELECTROMAGNETIC FIELDS



J. N. Towle / In AGARD Propagation Limitations in Remote Sensing Oct 1971 9 p refs (See N72-16085 07-07)  
(Grants NSF GK-2311 NSF GK-21218)  
Avail NTIS HC \$6.00/MF \$0.95

For the purposes of magneto-telluric exploration the penetration of electromagnetic energy into the conducting strata presented by the earth's crust may be described by the parabolic equation of diffusion with a spatially dependent coefficient. A difference-differential solution to this equation is implemented on a hybrid computer and the resulting time dependent solutions are studied. Boundary conditions of the Neumann type, corresponding to the specification of magnetic field on the boundary, are appropriate for the determination of electric field in the conducting medium. The additional boundary conditions imposed by specification of electric field on the boundary provides the necessary information for the synthesis of a previously unknown conductivity profile. Author

N72-16119# Kansas Univ., Lawrence

**WORKSHOP ON RADAR SCATTERING HELD TUESDAY AFTERNOON 22 JUNE 1971**

R. K. Moore / In AGARD Propagation Limitations in Remote Sensing Oct 1971 7 p (See N72-16085 07-07)

Avail NTIS HC \$6.00/MF \$0.95

Three topics are discussed: Radar backscatter from the sea, the need for microwave data on dielectric properties of natural surfaces and objects, and slant-range measurements by the nanosecond pulse radar. The most significant conclusion to emerge is that insufficient data are available on the dielectric constants of natural materials (ice, vegetation, soil) measured in situ. Author

N72-21121# Advisory Group for Aerospace Research and Development, Paris (France)

**RADAR PROPAGATION IN THE ARCTIC**

Jon Frihagen, ed. Jan 1972 430 p refs. Presented at Specialists Meeting of the Electromagnetic Wave Propagation Panel of AGARD, Lindau/Harz, West Germany, 13-17 Sep. 1971

(AGARD-CP-97) Avail NTIS HC \$8.00/MF \$0.95

The characteristics and effects of the Arctic ionosphere on radio and radar propagation are considered. Experimental and theoretical efforts in the field are reviewed. For individual titles, see N72-21122 through N72-21153

N72-21122# Communications Research Centre, Ottawa (Ontario)

**MORPHOLOGY OF RADIO-RADAR POLAR PROPAGATION EFFECTS**

T. R. Hartz / In AGARD Radar Propagation in the Arctic Jan 1972 18 p refs (See N72-21121 12-07)

Avail NTIS HC \$8.00/MF \$0.95

A variety of observational data are reviewed for the polar upper atmosphere, and particularly for morphological patterns deduced for particle precipitation associated with auroral phenomena and with polar cap disturbances. The significance of different portions of such patterns are discussed with reference to particle energies, sources, and ionospheric changes during disturbed intervals. Statistical data are given on the diurnal, seasonal, and spatial variation of such associated propagation effects as absorption, scintillation, dispersion etc., along with their correlation with magnetic activity, spread F, sporadic E, visual aurora, and radio noise observations. In addition, the storm time variation of some of these phenomena are discussed from the point of view of their short term effects on radio wave propagation. Author

N72-21123# Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.

**UI: MODELLING THE ARCTIC IONOSPHERE**

G. J. Gassman / In AGARD Radar Propagation in the Arctic Jan 1972 20 p refs (See N72-21121 12-07)

Avail NTIS HC \$8.00/MF \$0.95

It appears that the prediction of the Arctic ionosphere in the manner and with the accuracy accomplished for moderate latitudes is not yet possible. However, from already established general patterns, it seems feasible to provide an hourly updated and fairly accurate description by real time processing of data from a few observing stations. A number of suitable observing techniques are discussed. Author

N72-21124# Imperial Coll. of Science and Technology, London (England), Physics Dept.

**THE POLAR EXOSPHERIC PLASMA**

J. O. Thomas and A. D. R. Phelps / In AGARD Radar Propagation in the Arctic Jan 1972 11 p refs (See N72-21121 12-07)

Avail NTIS HC \$6.00/MF \$0.95

The main features of the spatial distribution of plasma in the earth's polar exosphere deduced from satellite observations are described and related to recent measurements of incoming particles of magnetospheric origin, particularly in the low energy range (about 1000 eV). The topics include: (1) the termination of the terrestrial plasmasphere, (2) the identification and location of a ring or torus of enhanced plasma density surrounding each pole stationary with respect to the sun, and under which the earth rotates, (3) the geomagnetic control of ionization, with the recognition of effects occurring at certain universal times associated with the geometry of the geomagnetic axis earth-sun line system; and (4) the polar wind. Some of the main physical processes contributing to both static as well as dynamic features of the overall structure of the polar plasma distribution are introduced. Author

N72-21125# Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.

**A DISCUSSION OF ARCTIC IONOGRAMS**

R. A. Wagner and C. P. Pike / In AGARD Radar Propagation in the Arctic Jan 1972 20 p refs (See N72-21121 12-07)

Avail NTIS HC \$6.00/MF \$0.95

Examples of Arctic ionogram sequences, recorded on the AFCRL flying ionospheric laboratory, are presented. It is shown that: (1) ionogram sequences facilitate the interpretation of oblique incidence echoes from E and F layer heights; (2) Parameters of the Arctic ionosphere can be mapped by using the auroral oval as an ordering system; (3) Vertical and oblique incidence echoes appearing on ground station ionograms can be interpreted in terms of the station's position relative to the auroral oval. The analysis of a three-hour flight with six latitudinal scans underneath an aurora and shows the close relationship between auroral-type sporadic echoes and discrete auroras. The investigation of 43 latitudinal scans through the auroral oval during times of low magnetic activity revealed the existence of a particle-produced E layer which is oval-aligned, is 2 to 6 deg wide in corrected geomagnetic latitude and occurs at all corrected geomagnetic times. This layer produces the night E layer. An ionogram analysis procedure which uses oblique incidence F layer echoes is demonstrated, and the feasibility is suggested of monitoring the latitude of the southern edge of the polar F layer irregularity zone by using this technique. Author

N72-21126# Stanford Research Inst., Menlo Park, Calif.

**POLAR PROPAGATION EFFECTS ON VHF-UHF RADARS**

Walter G. Chestnut / In AGARD Radar Propagation in the Arctic Jan 1972 38 p refs (See N72-21121 12-07)

Avail NTIS HC \$8.00/MF \$0.95

The effects upon VHF-UHF radar which are considered are wave distortions caused by wave interaction with E and F region auroral ionization, including auroral backscatter (auroral clutter) and forward scatter that leads to amplitude and angle scintillation. Recent results of pulse-radar-backscatter studies from aurora are reviewed and theories of irregularity production are considered. Aurorally produced radar tracking and amplitude scintillation are discussed. Some results from aurorally disturbed monopulse tracking of satellites are presented. Author

**N72-21127#** National Research Council of Canada, Ottawa (Ontario), Astrophysics Branch.

**OBSERVATIONS OF 48 MHz AURORAL RADAR PROPAGATION ON A NETWORK IN THE AURORAL ZONE**

A. G. McNamara *In* AGARD Radar Propagations in the Arctic Jan. 1972. 8 p refs (See N72-21121 12-07)

Avail: NTIS HC \$6.00/MF \$0.95

Four auroral radars are operated on a continuous basis at Ottawa, Thompson, Churchill, and Great Whale in Canada. The Ottawa radar is at 40 deg latitude and the other three are at approximately 57 deg in the auroral zone. The high incidence of auroral activity at these locations permits both statistical and detailed single event studies of radio aurora morphology and scattering mechanisms. In spite of magnetic aspect control, strong auroral backscatter signals are detected at all azimuths with aspect angles of up to 25 deg from the magnetic perpendicular. These observations create difficulties in explaining radar aurora in terms of ion-acoustic waves developed from linear models such as the two-stream instability theory. As well as direct auroral backscatter, the radars sometimes detect sporadic E propagated ground scatter, usually in association with auroral disturbance. The simultaneous observations of these auroral phenomena by the multiple stations permit more definitive measurements of the processes involved. Author

**N72-21128#** Max-Planck-Institut fuer Aeronomie, Lindau Ober Norheim (West Germany)

**CURRENT EXPERIMENTAL RESULTS FROM A VHF-CW AURORAL BACKSCATTER NETWORK IN SCANDINAVIA**

G. Lange-Hesse *In* AGARD Radar Propagation in the Arctic Jan. 1972. 16 p refs (See N72-21121 12-07)

Avail: NTIS HC \$6.00/MF \$0.95

VHF bistatic, continuous wave auroral backscatter communications (radio aurora) carried out since autumn 1967 on a network in Scandinavia and northern Germany were analyzed with respect to the influence of daytime, seasonal, and geomagnetic latitude on frequency occurrence. Examples are presented which show the close control of the VHF auroral backscatter by the polar electrojet. Examples are given for the correlation between optical and radio aurora. Author

**N72-21129#** Stanford Research Inst., Menlo Park, Calif.  
**AURORAL RADAR BACKSCATTER STUDIES FROM HOMER, ALASKA**

W. G. Chestnut, J. C. Hodges, and R. L. Leadabrand *In* AGARD Radar Propagation in the Arctic Jan. 1972. 11 p refs. Sponsored in part by DASA, NSF, and RADC (See N72-21121 12-07)

Avail: NTIS HC \$6.00/MF \$0.95

Radar aurora were studied using a backscatter radar at six frequencies from 50 MHz to 3000 MHz. It was found that the frequency dependence of the volume scattering cross section of the auroral echoes is nearly exponential with frequency. The slope of this frequency dependence was found to vary with time but averaged 33 db per 1000 MHz. The magnetic aspect sensitivity was found to be nearly independent of frequency; the scattering cross section decreased by about 10 db per degree of aspect angle. Auroral radar echoes at a frequency of 139 MHz were compared with the location of particle precipitation as measured during fourteen passes of the OV1-18 satellite. It is found that, except for periods of very active aurora, nighttime radar aurora was never collocated with peaks in proton energy flux. Where a radar aurora was located, measured particle precipitation fluxes were adequate to produce equilibrium E region electron densities greater than 70,000 el/cc. Thus E region electron densities necessary for radar auroras seem to be produced by precipitating particles. Author

**N72-21130#** Lincoln Lab., Mass. Inst. of Tech., Lexington  
**SOME PROPERTIES OF RADAR AURORAL ECHOES AS OBSERVED AT A FREQUENCY OF 1295 MHz**

T. Hegfors *In* AGARD Radar Propagation in the Arctic Jan. 1972. 16 p refs (See N72-21121 12-07)

Avail: NTIS HC \$6.00/MF \$0.95

Observations are described of radar auroras made at a frequency of 1295 MHz from Millstone Hill, Massachusetts. From maps of power returned versus azimuth, elevation angle, and range of specific events of diffuse aurora, it was found that a mean height of auroral echoes is close to 110 km, that the half power thickness is 7 km, and that the power scattered drops 3 db when the aspect angle with respect to the magnetic field is increased from zero to 0.4 deg. Spectral analysis of echoes returned from a volume of 10 x 10 x 10 cu km with a resolution of 600 Hz reveals a great variety of spectra, many of which are narrow and displaced as if from an ion-acoustic density instability. Other spectra are wide and contain contributions from approaching and receding waves simultaneously. The wide spectra apparently are associated with regions where the radar beam is normal to the electrojet current. Simultaneous observations of auroral echoes and particle precipitation show that radio auroras may be observed without any measurable electron precipitation. Author

**N72-21131#** National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.

**MICROSTRUCTURE OF RADIO AURORA SCATTERING REGIONS**

A. Egeland (Oslo Univ., Norway), J. Holtet (Oslo Univ., Norway), and N. C. Maynard *In* AGARD Radar Propagation in the Arctic Jan. 1972. 11 p refs (See N72-21121 12-07)

(NASA-TM-X-68302) Avail: NTIS CSCL 20N

Summaries are presented for studies of radio scattering from auroral ionization. Analyses were made of auroral returns from scaled, pencil beam radio systems. A brief discussion of scattering theories is given. Measurements of small scale fields, particle precipitation, and auroras are described. The microstructure and dynamics of auroras are also considered. Author

**N72-21132#** Western Ontario Univ., London, Centre for Radio Science

**ION-ACOUSTIC WAVES IN AURORA**

P. A. Forsyth and G. F. Lyon *In* AGARD Radar Propagation in the Arctic Jan. 1972. 5 p refs (See N72-21121 12-07)

Avail: NTIS HC \$6.00/MF \$0.95

Evidence is presented that ion-acoustic waves exist in the auroral plasma and that these waves contribute to the scattering of radio waves at both VHF and UHF frequencies. Recent results suggest that this kind of clutter will be observed even at latitudes where the line-of-sight may not be perpendicular to the magnetic field lines. It is also suggested that ion-acoustic waves may contribute to the angular scintillations observed at high latitudes for transionospheric propagation paths using UHF radio waves. Author

**N72-21133#** Saskatchewan Univ., Saskatoon, Inst. of Atmospheric Studies

**POLARIZATION OF WAVES SCATTERED FROM AURORA**

A. Kavadas *In* AGARD Radar Propagation in the Arctic Jan. 1972. 13 p refs (See N72-21121 12-07)

Avail: NTIS HC \$6.00/MF \$0.95

Various interactions which lead to depolarization and cross-polarization are examined and correlated to particular types of aurora and properties of the scattering medium. Experimental results obtained from complete polarization measurements are used to demonstrate the nature of these interactions and the resulting changes in the polarization of the propagating wave. The experimental results were obtained with a time-sharing polarimeter which recorded six orthogonal components of aurorally backscattered waves at 42 MHz. Waves scattered in the forward direction were studied with partial polarization measurements (two orthogonal components) of radio star scintillations. The polarization of the received wave correlates with magnetic activity. Author

**N72-21134#** Royal Radar Establishment, Malvern (England).  
**NONSPECULAR IONOSPHERIC CLUTTER IN THE VHF AND UHF BANDS**

G. N. Taylor *In* AGARD Radar Propagation in the Arctic Jan. 1972 9 p refs (See N72-21121 12-07)  
 Avail: NTIS HC \$6.00/MF \$0.95

The intensity of weak scattering from electron density irregularities in the high latitude ionosphere, in directions not perpendicular to the magnetic field is considered. Signals may cause clutter in sensitive radar systems at wavelengths between 10m and 0.1m. The literature is surveyed, to obtain typical and worst case values of the rms density deviation and scale size of the irregularities, and to select appropriate spatial autocorrelation functions. Assuming an isotropic distribution, scattering cross sections are calculated. It is concluded that nonspecular clutter is not likely to be more intense than the background incoherent (Thomson) scatter signals at wavelengths less than about 4m, unless the scf becomes markedly non-Gaussian. The spatial variability and spectral characteristics of incoherent and nonspecular clutter signals are discussed briefly. Author

**N72-21135#** Battelle Memorial Inst., Columbus, Ohio  
**A PROGRAM FOR THE INVESTIGATION AND SIMULATION OF AURORAL INSTABILITY MECHANISMS**

J. T. Coleman *In* AGARD Radar Propagation in the Arctic Jan. 1972 11 p refs (See N72-21121 12-07)  
 Avail: NTIS HC \$6.00/MF \$0.95

A program is described for the simulation and analytical investigation of the scattering mechanisms of the radio aurora. The program is divided into two parts: the first is a simulation, on a scaled basis, of the important plasma mechanisms of the E region and its scattering conditions, and the second is a computation of the theoretical coherent interaction instability cross sections. Experimental evidence is presented for sensitivity of the coherent cross section to the drift current level, the local electron temperature, the local magnetic field intensity, gradients, and other parameters. The theoretical model estimates the differential radar cross section (in the hydrodynamic approximation) and includes the effects of relative drift between ions and electrons, and the gradient in electron density. In its present form, the model includes forward scatter, backscatter, and general bistatic scatter. The computation includes the frequency spectrum introduced by interaction with wave instabilities. Author

**N72-21136#** Raytheon Co., Sudbury, Mass.  
**PHASE COHERENT HF RADAR OBSERVATIONS OF BARIUM RELEASES IN THE ARCTIC IONOSPHERE**

G. D. Thome *In* AGARD Radar Propagation in the Arctic Jan. 1972 6 p ref (See N72-21121 12-07)  
 Avail: NTIS HC \$6.00/MF \$0.95

Radar observations are reported which show that the development of optical striations is accompanied by an abrupt broadening of the Doppler spectrum, leading to returns with Doppler widths comparable to those observed from the natural radio aurora. In contrast to the natural ionosphere, the barium plasma is generated at a known instant of time and is confined to a limited volume of space. This makes it possible to study the evolution of irregularities in this plasma as a function of time and to study their radar aspect sensitivity without using narrow beam antennas. Prior to optical striation development, the barium cloud behaves as a smooth overdense target, exhibiting a discrete Doppler spectrum and producing regular Faraday fading. After the development of striations, the Doppler spectrum becomes diffuse and Faraday fading is lost. Author

**N72-21137#** Kiruna Geophysical Observatory (Sweden).  
**POLAR PROPAGATION EFFECTS ON RADIO-ASTRONOMICAL AND SATELLITE TRANSMISSIONS**

Ludwik Liszka *In* AGARD Radar Propagation in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)  
 Avail: NTIS HC \$6.00/MF \$0.95

High latitude studies of scintillation phenomenon in radio signals from radio astronomy sources and satellites are reviewed.

Morphology of high latitude scintillation is discussed, including geographic distribution, diurnal variations, and relation to magnetic activity. Studies of statistical properties of the signal received on the ground were found to be a useful source of information about the nature of irregularities in the ionosphere. Studies are reviewed with emphasis on parameters of the scintillation-producing layer. Finally, results of height determinations using the space receiver method and satellite transmissions are briefly discussed. Author

**N72-21138#** Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.

**SATELLITE SCINTILLATIONS IN THE HIGH LATITUDE F-LAYER IRREGULARITY REGION**

Jules Aarons *In* AGARD Radar Propagation in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)  
 Avail: NTIS HC \$6.00/MF \$0.95

Polar observations from Spitzbergen show a trough or decrease in scintillation index, on the right side between an oval and a polar region. Using radio star data at 113 and 228 MHz, scintillation index increases of 0.50 to 7 were noted with increases in K index (propagation path intersection through the F layer (350 km) at 67 deg). Recordings of 136 MHz satellite signals from Narsarsuaq, Greenland also show that mean scintillation index increases during magnetic storms within the irregularity region. Thule observations of 40 MHz transmissions indicate the overhead pattern at invariant latitudes near 86 deg. A model is presented of a core of high electron density irregularities, probably centered above the auroral oval, but with a high occurrence of irregularities over the polar cap. In addition, the irregularity region at lower intensity extends below the oval at night. Author

**N72-21139#** Western Ontario Univ., London, Centre for Radio Science.

**ANGULAR DEVIATION OF RADIO WAVES**

G. F. Lyon and P. A. Forsyth *In* AGARD Radar Propagation in the Arctic Jan. 1972 5 p refs (See N72-21121 12-07)  
 Avail: NTIS HC \$6.00/MF \$0.95

Angular deviations due to typical departures from horizontal stratification are modelled. In particular, the steep gradients and troughs in electron density typical of the polar ionosphere are considered. The results suggest that systems which depend upon precise measurements of angle of arrival for radio waves in the frequency range at least to the upper end of the VHF range may be subject to significant unavoidable error. Author

**N72-21140#** Norwegian Defence Research Establishment, Kjeller.

**HIGH LATITUDE SATELLITE SCINTILLATION**

J. Frihagen and O. Bratteng (Auroral Obs., Tromsø, Norway) *In* AGARD Radar Propagation in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)

Avail: NTIS HC \$6.00/MF \$0.95

Numerous measurements of the height of ionospheric irregularities giving rise to satellite scintillation have shown them to be located in the region 300-600 km above the ground. Observations show that there is no appreciable reduction in scintillation at 136 MHz when a satellite loses height from in excess of 1000 km to less than 300 km. When observed from Tromsø (70 deg N) the mean scintillation depth at 136 MHz increases from south to north, increases with K, shows nighttime maxima and daytime minima. Some results of electron density from rockets launched from Andenes (69 deg N, 16 deg E) show strong irregularities, the electron density varying by up to 25% over a few tens of meters north of auroral forms. Over the auroral forms, the electron density varies smoothly. Author

**N72-21141#** Max-Planck-Institut fuer Aeronomie, Lindau Ueber Northeim (West Germany)

**SATELLITE SCINTILLATION BETWEEN 43 DEG AND 65 DEG NORTH LATITUDE FROM 1964 TO 1969**

Gerd K. Hartmann *In* AGARD Radar Propagation in the Arctic Jan. 1972 12 p refs (See N72-21121 12-07)  
Avail. NTIS HC \$6.00/MF \$0.95

Since November 1964 till May 1969 the radio signals from the beacon satellite Explorer 22 were continuously recorded at Lindau, for obtaining the ionospheric electron content from Faraday-effect- and dispersive-Doppler-effect measurements. The obtained amplitude and phase recordings were compared. When the root mean square phase deviation, during distortions, e.g. phase scintillation, was equal or greater 1 radian, fast amplitude scintillations that exceeded 6 dB amplitude variations were found. The narrow scintillation belt, which was observed between 60 deg and 60 deg northern geographic latitude consists of two independent sub-belts. It is suggested that the scintillation activity increases by a factor of 2 for weak scintillations and by a factor of 4 strong scintillations, when  $K_p$  exceeds 3c. A southward motion with increasing magnetic activity was observed. In summer the SOFM seems to be approximately 2 deg further north than in winter. Author

N72-21142# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany).

#### POLAR PROPAGATION EFFECTS ON HF RADARS

H. G. Moeller *In* AGARD Radar Propagation in the Arctic Jan. 1972 15 p refs (See N72-21121 12-07)  
Avail. NTIS HC \$6.00/MF \$0.95

The CW and pulse transmission experiments in the auroral and subauroral region are reviewed. The phenomena that affect propagation are dispersion of F2 critical frequency and hence horizontal electron density gradients, field-aligned irregularities in the F2 and E region, auroral Es, and D region absorption. The variation of these phenomena in time and space and the correlation with magnetic activity are discussed. Following propagation, effects were observed due to these phenomena. Transmission paths transversing horizontal gradients of electron density become asymmetric which has to be taken into account in MUF calculations. Strong curtains of irregularities cause non-great-circle transmission. The NGR transmission may be advantageous if it results in a MUF enhancement, or in bypassing an area of enhanced absorption, it is disadvantageous as time delay of the received signals is increased. The enhancement is often observed by auroral Es. Author

N72-21143# Stanford Research Inst., Menlo Park, Calif.  
FREQUENCY DISTORTION IN AURORAL HF PROPAGATION

J. S. Lomax *In* AGARD Radar Propagation in the Arctic Jan. 1972 12 p refs (See N72-21121 12-07)  
Avail. NTIS HC \$6.00/MF \$0.95

The HF propagation in auroral regions results in greater frequency distortion of signals than that encountered at mid-latitudes. Observational data on the characteristics of this distortion as taken on a transauroral path between Palo Alto, California and Thule, Greenland are presented. Details of the frequency distortion are given in terms of measured power spectral densities, Doppler shifts, and the corresponding phase fluctuations. These quantities are in turn related to the temporal correlation function of the channel. Author

N72-21144# Home Air Development Center, Griffiss AFB, N.Y.  
HIGH ALTITUDE HF SIGNAL TRANSMISSION CHARACTERISTICS

R. A. Mather, B. L. Holtzclaw (GE Co., Syracuse, N. Y.), and R. W. Swanson (GE Co., Syracuse, N. Y.) *In* AGARD Radar Propagation in the Arctic Jan. 1972 22 p refs (See N72-21121 12-07)  
(Contract F30602-69-C-0217)  
Avail. NTIS HC \$6.00/MF \$0.95

Measurements made on HF sky wave signals propagated over two high-latitude 2000 nmi paths terminating at a receiving site in central New York State are presented. Signal characteristics include propagation loss, spectral spreading, and temporal

spreading as a function of signal bandwidth (either 7.7 kHz or 100 kHz). The transmitting sites were located at Thule, Greenland and Keflavik, Iceland so that HF propagation information could be collected on a path that was both in the polar cap region and in midlatitude, and on one that passes along and through the outer edge of the auroral oval. Oblique soundings were conducted over each path so that the mode(s) of propagation for the signal(s) measured could be determined. Analyses of the results obtained indicated that the spectral and temporal spreading are a very strong function of the mode of propagation, especially for signals transmitted over the Thule path. The data are depicted as a function of time of day to illustrate the diurnal variation of the parameters considered. Author

N72-21145# Radio and Space Research Station, Slough (England).

#### POLARIZATION EFFECTS ON SKY-WAVE PATHS AT HIGH LATITUDES

P. A. Bradley *In* AGARD Radar Propagation in the Arctic Jan. 1972 9 p refs (See N72-21121 12-07)  
Avail. NTIS HC \$6.00/MF \$0.95

The principles involved in the determination of polarization coupling losses on sky-wave paths are briefly discussed. The way these losses depend on the limiting polarizations of the upgoing and downcoming waves at the bottom of the ionosphere are illustrated, and it is shown that at frequencies in excess of about 2 MHz simple expressions are available for these limiting polarizations which are independent of the form of the ionization profiles. Limiting polarizations and polarization coupling losses are functions of wave frequency and of ray-path directions with respect to the direction of the earth's magnetic field. At high latitudes, changes in the angle between the field and ray path directions lead to marked variations in polarization coupling losses for nearby paths. Sample calculations are presented for a range of conditions to illustrate single- and two-way path losses. The calculations include the case of two-hop paths where there are additional features associated with the change of polarization at ground reflection. The results show the importance of the optimum choice of aerial polarization. The way in which backscatter amplitude return patterns can be influenced by polarization effects is also illustrated. Author

N72-21146# Air Force Cambridge Research Labs., L. G. Hanson Field, Mass.

#### SPATIAL CORRELATION OF AURORAL RADIO ABSORPTION

K. Toman, R. J. Cormier, and J. J. Corbett *In* AGARD Radar Propagation in the Arctic Jan. 1972 9 p refs (See N72-21121 12-07)  
(Contract F19628-70-C-0237)  
Avail. NTIS HC \$6.00/MF \$0.95

The temporal behavior of auroral radio absorption was measured with riometers at medium and high latitude displays complex patterns which differ spatially. These differences may be limited to a time displacement of otherwise similar absorption patterns indicating a movement which could be interpreted in terms of a structured, locally enhanced, precipitating, energetic particle stream that moves over a geographic area. In order to assess numerically the spatial coherence of auroral radio absorption, a correlation study was undertaken of absorption patterns as recorded by more than eight riometer stations during five days of varying activity containing the magnetic storm of 18 April 1965. Using a day as the sample size, the results of this study provide a view of the spatial coherence of auroral absorption. Author

N72-21147# Alaska Univ., College. Geophysical Inst.  
SWEEP FREQUENCY BACKSCATTER RADARS AS DETECTORS OF HIGH LATITUDE IONOSPHERIC PHENOMENA

Howard F. Bates *In* AGARD Radar Propagation in the Arctic Jan. 1972 9p refs (See N72-21121 12-07)  
Avail. NTIS HC \$6.00/MF \$0.95

Characteristics of irregularities causing high frequency scatter and propagation problems are examined, along with auroras producing these large and small scale irregularities. Auroral and nonauroral echoes were identified through high latitude, high frequency backscatter. Nonauroral echoes consist of F layer ground scatter, nonauroral sporadic E including E ground scatter, meteor echoes, and oblique spread F echoes. Auroral echoes were found to be caused by backscatter from both the E and F layers. J.A.M.

**N72-21148#** Technical Univ. of Denmark, Lyngby.  
**ON THE POLAR SLANT E CONDITION, ITS IDENTIFICATION, MORPHOLOGY AND RELATIONSHIP TO OTHER ELECTROJET PHENOMENA**

Jens K. Olesen / In AGARD Radar Propagation in the Arctic Jan. 1972 19 p refs (See N72-21121 12-07)  
 Avail. NTIS HC \$6.00/MF \$0.95

Ionograms and morphological statistics of polar slant E condition are discussed, emphasizing two stream or plasma ion wave instability. Observation sites and data periods for ionosonde and fixed frequency scatter measurements are also listed. J.A.M.

**N72-21149#** Paris Univ. (France).  
**HIGH FREQUENCY BACKSCATTER OBSERVATIONS AT MEDIUM LATITUDES OF HIGH LATITUDE FIELD ALIGNED IRREGULARITIES**

M. Crochet, D. Barreau, and J. C. deMaistre / In AGARD Radar Propagation in the Arctic Jan. 1972 9 p refs In FRENCH; ENGLISH summary (See N72-21121 12-07)  
 Avail. NTIS HC \$6.00/MF \$0.95

Abnormal echoes ascribable to the presence of field aligned high latitude irregularities in the F layer were frequently observed from the Valensole station (44 deg N, 6 deg E), by means of decametric wave backscatter radar. A comparison of characteristic recordings with data collected simultaneously at the Lindau station (51 deg N, 10 deg E) where such echoes are regularly obtained reveals the influence of the station latitude on the observation of such phenomena. Author

**N72-21150#** Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.  
**HF AURORAL BACKSCATTER AND THE SCINTILLATION BOUNDARY**

Jules Aarons / In AGARD Radar Propagation in the Arctic Jan. 1972 11 p refs (See N72-21121 12-07)  
 Avail. NTIS HC \$6.00/MF \$0.95

A 19 MHz backscatter unit was operated, and a series of measurements of radio star scintillations (30 to 228 MHz) and satellite beacon recordings (20 to 136 MHz) were made. A 50 MHz radar was added to the observing program. In a recent analysis of the dual frequency field aligned backscatter, a separation into E and F-layer returns was made. It was found that VHF auroral returns (from E-layer heights) were accompanied 49% of the time by HF returns. The two factors suggested to be responsible for the absence of a 1:1 correlation were probably absorption at HF and variations in antenna launch angle for the two systems. The HF auroral backscatter (E and F-layer heights) was accompanied only 11% of the time by VHF backscatter. During the 17 months of observation at low solar activity, the percentage of occurrence of 19 MHz field aligned scatter was 2%; of 50 MHz auroral scatter 0.5%. Author

**N72-21151#** Avco Corp., Wilmington, Mass.  
**FM/CW HF BACKSCATTER OBSERVATIONS OF RADIO AURORA**

A. H. Katz / In AGARD Radar Propagation in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)  
 (Contract F30602-70-C-0086)  
 Avail. NTIS HC \$6.00/MF \$0.95

Observations of HF backscatter from radio aurora using an FM/CW radar located at field sites near Rome, N. Y. (43.2 deg N, 75.5 deg W) are discussed. Both wideband (at 6.5-30 MHz, 3 kW average power) and narrowband (fixed frequency soundings at 20 kW average power) backscatter measurements were made. The wideband soundings determine the modes of propagation, frequency extents, and time delays of the backscattered energy. The high resolution narrowband soundings indicate the movements that occur in the radio auroral regions. Examples of these motions are presented, showing events that last for 5 minutes, exhibiting range changes which imply apparent velocities near or above the speed of sound at F-region heights. The wideband backscatter measurements were processed in a form which allows the absolute signal level of the backscattered energy to be determined. Author

**N72-21152#** General Electric Co., Syracuse, N.Y.  
**IONOSPHERIC REFRACTION EFFECT ON THE GEOMETRY OF FIELD-ALIGNED IONIZATION**

George H. Millman / In AGARD Radar Propagation in the Arctic Jan. 1972 15 p refs (See N72-21121 12-07)  
 Avail. NTIS HC \$6.00/MF \$0.95

A method is presented which utilizes the concept of the ionospheric refraction phenomenon in the calculation of the magnetic field-propagation aspect angle. The effect of ionospheric refraction at frequencies in the HF-UHF band is evaluated for one location in the Northern Hemisphere. Author

**N72-21153#** Institute for Telecommunication Sciences, Boulder, Colo.  
**A MODEL FOR THE STUDY AND PREDICTION OF AURORAL EFFECTS ON HF RADAR**

Vaughn Agy / In AGARD Radar Propagation in the Arctic Jan. 1972 10 p refs (See N72-21121 12-07)  
 Avail. NTIS HC \$6.00/MF \$0.95

A description is given of an ionospheric propagation model and its application to high latitude HF radar propagation. Computer simulation of the model makes possible the rapid determination of the area of (1-hop) coverage, and computation of auroral absorption and geometrical features of auroral clutter. The results are presented in a map on which are shown appropriate parameter contours. Operating frequency, station location, time, month, sunspot number, and clutter height are all arbitrary. The explicit approximations specifying the model can be changed within the basic framework of the computer program to bring about better agreement with observations. Author

**N72-22136#** Advisory Group for Aerospace Research and Development, Paris (France).  
**TECHNICAL EVALUATION REPORT ON AGARD SPECIALISTS MEETING ON RADAR**

J. Frihagen (Norwegian Defense Res. Estab., Kjeller) Jan. 1972 21 p refs Conf. held at Lindau/Harz, West Germany, 13-17 Sep. 1971  
 (AGARD-AR-33) Avail. NTIS

A conference on radar propagation in the Arctic is presented, including sessions on polar morphology, VHF-UHF propagation backscatter, polar scintillation, VHF propagation transmission, and HF propagation backscatter. Summaries, recommendations, and future studies are considered for radio aurora, radar aurora, VHF-UHF incoherent scatter, scintillation, and satellite beacon studies. Backscatter observations and HF scatter and communications are also reviewed. J.A.M.

**N73-10187#** Advisory Group for Aerospace Research and Development, Paris (France).  
**AEROSPACE TELECOMMUNICATIONS SYSTEMS**

Aug. 1972 355 p refs Partly in ENGLISH and partly in FRENCH. Proc. of the 23d Tech. Meeting of the Avionics Panel of AGARD, London, 15-18 May 1972  
 (AGARD-CP-103) Avail. NTIS HC \$19.75

Expanded telecommunication system requirements can be

met by data compression methods and digital imaging schemes, efficient bandwidth utilization and adaptation techniques, tactical environment ground terminal measurements for satellite communications, and digital/analog communications for automatic message systems and interference suppression. For individual titles, see N73-10188 through N73-10213.

**N73-10188** Royal Aircraft Establishment, Farnborough (England). Radio Dept.

**TECHNICAL EVALUATION REPORT ON 23D AVIONICS PANEL TECHNICAL MEETING ON AEROSPACE TELECOMMUNICATIONS SYSTEMS, 15-18 MAY 1972**

P. G. Whicher. In AGARD Aerospace Telecommun. Systems Aug 1972. 9 p (For availability see N73-10187 01-07)

Activities in telecommunications research and development, and in network planning, monitoring, and utilization are reported. An important conclusion formed states that digital techniques offer real prospects of supplanting traditional analog methods in a wide range of future applications in aerospace systems. Emphasis is placed on growing problems of electromagnetic compatibility, interference, and jamming and the difficulties of accommodating multiple satellite systems in synchronous orbit. G.G.

**N73-10189** Laboratoire Central de Recherches Thomson-CSF, Orsay (France). Div. Matériels Avioniques et Spatiaux.

**REDUCTION OF APPLIED REDUNDANCY IN THE TRANSMISSION OF IMAGES [REDUCTION DE LA REDONDANCE APPLIQUEE A LA TRANSMISSION DES IMAGES]**

T. A. Hawkes and P. A. Simonpietri. In AGARD Aerospace Telecommun. Systems Aug 1972. 14 p. refs. In FRENCH (For availability see N73-10187 01-07)

A procedure relevant to the simple reduction of applied redundancy in image transmission is presented. The algorithm treatment and known reception permits the reconstruction of signals without transmitting the information over the length of the pattern interval. After an evaluation of all possible procedures, the effect of first simulation elements on the ordinates of the proposed algorithm with image restoration imprints is examined. Essential parameters, functions of the system, and the results obtained are given. Transl. by E.H.W.

**N73-10190** Perkin-Elmer Corp., Norwalk, Conn.

**DIFFERENTIAL PULSE CODE MODULATION TRANSMISSION OF SAMPLED AERIAL IMAGERY**

R. J. Arguello, H. R. Sellner, and J. A. Stuller. In AGARD Aerospace Telecommun. Systems Aug 1972. 20 p. refs. (For availability see N73-10187 01-07)

An analysis, simulation and discussion of the effects of quantizer noise and communication errors on differential pulse code modulation (DPCM) transmission of sampled aerial imagery are reported. Simulations are presented that describe: (1) DPCM transmission of photographic scenes which have been scanned and sampled at the Nyquist rate, and (2) the effects of inserting periodic PCM updates in order to correct DPCM communication errors. Two, three and four bit DPCM transmission systems are discussed. Author

**N73-10191** Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.

**COMPUTER AIDED EVALUATION OF RECONNAISSANCE IMAGE COMPRESSION SCHEMES USING AN ON-LINE INTERACTIVE FACILITY**

J. C. Mott-Smith, F. H. Cook, and J. M. Knight (Mitre Corp., Bedford, Mass.). In AGARD Aerospace Telecommun. Systems Aug 1972. 20 p. refs. (For availability see N73-10187 01-07) (Contract F19828-71-C-0002)

A method is proposed of evaluating compression algorithms applied to pictures and applied to several well-known techniques, most of which already have one or more hardware implementations. General conclusions are that delta modulation and differential pulse code modulation which use three or fewer bits per picture element are detrimental, and that the zero- and first-order predictors may give some compression but certainly less than a factor of two on the average. The defects in the algorithms which limit their usefulness on pictorial data is identified with their poor correlation from one line of the picture to the

next. The importance of proper data management for pictorial communication is illustrated, and by implication, shown to be much more important than the data compression algorithms. Relevant to the data management proposals, some methods of improving the cosmetic quality of sparsely sampled images are shown. Author

**N73-10192** Rensselaer Polytechnic Inst., Troy, N.Y. Systems Engineering Div.

**A TUTORIAL ON DIGITAL TECHNOLOGY WITH EMPHASIS ON DIGITAL COMMUNICATIONS AND FILTERING**

Lester A. Gerhardt. In AGARD Aerospace Telecommun. Systems Aug 1972. 7 p. refs. (For availability see N73-10187 01-07) (Contracts AF 49(638)-1627, DAAB07-68-C-0365)

The major advantages of a digital approach to communications are considered and digital technology and its effect on communications are outlined. Under the umbrella of a generalized model of a digital communications system, the status of the theory is reviewed and practical implementations are given. The relationship between theory and practice is emphasized using digital filtering as typical of the achievements in this area. Author

**N73-10193** Politecnico di Torino (Italy). Is. di Elettronica e Telecomunicazioni.

**ON THE EFFICIENT BANDWIDTH UTILIZATION IN DIGITAL TRANSMISSION**

S. Benedetto, V. Castellani, C. Cianci (Centro Studi e Laboratori Telecomunicazioni), and U. Mizzari (Studi e Laboratori Telecomunicazioni). In AGARD Aerospace Telecommun. Systems Aug 1972. 13 p. refs. (For availability see N73-10187 01-07)

The problem of the efficient bandwidth utilization of a digital transmission channel is investigated by working out a complete example with a rather realistic channel model. The bandwidth efficiency in digital transmission is contrasted by the channel distortion impairments. A useful shaping of the signal spectrum and the use of a transversal equalizer are analyzed. Multilevel SSB amplitude modulated signals are assumed. System performances are discussed and evaluated using two different criteria: the peak distortion of the received signal and the average error probability of the received sequence. A general description of the different parts of the system is first given and a detailed discussion of the evaluation procedures is presented. Results are given for PAM and partial response coded (PRC) signalling schemes. System evaluation is finally discussed in terms of bandwidth efficiency. Author

**N73-10194** Service Technique des Telecommunications de l'Air, Paris (France).

**UTILIZATION AND SUPPLENESS OF HIGH NUMERICAL DISCHARGE SUPPORT IN TELECOMMUNICATIONS [UTILISATION ET SOUPLESSE D'UN SUPPORT NUMERIQUE A DEBIT ELEVE DANS UN SYSTEME DE TELECOMMUNICATIONS]**

G. Bomont (Service Tech. de la Navigation Aérienne), P. O. ... and G. David. In AGARD Aerospace Telecommun. Systems Aug 1972. 12 p. refs. In FRENCH (For availability see N73-10187 01-07)

The use of numerical control to compress syllabic delta modulated voice signals in air navigation telecommunication systems is discussed. The principles of the multiplexing numerical system and the transmission methods utilized are given. An organizational air navigation control system is illustrated. Transl. by E.H.W.

**N73-10195** Texas Instruments, Inc., Dallas.

**SYNTHESIS AND EVALUATION OF AN OPTIMUM SAMPLED DATA FM DEMODULATOR**

Alan L. McBride. In AGARD Aerospace Telecommun. Systems Aug 1972. 11 p. refs. (For availability see N73-10187 01-07) (Contract F30602-70-C-0180)

A digitalized or sampled-data FM demodulator recursive algorithm is synthesized and its signal-to-noise ratio performance evaluated. A recursive estimator is derived that optimally estimates the message of a noisy sampled FM process. The incoming analog noisy FM process is in-phase and quadrature sampled to reduce the bandpass RF waveform to a sampled baseband process.

The modulating process is modeled as a discrete linear filter by state variable techniques. The maximum a posteriori (MAP) criterion is used to develop a recursive cost function. Minimization techniques used in optimal control theory are employed to derive the two-point boundary-value (TPBV) problem from this cost function. Discrete invariant imbedding is then used to solve the TPBV problem and obtain the recursive solution algorithm. A single-pole message filter example is reviewed. Discussed in this example are performance curves obtained by simulation of the inverse output mean-square error versus input carrier-to-noise ratio. The demodulator is shown to exhibit FM threshold extension capability. Author

**N73-10196** Philco-Ford Corp., Palo Alto, Calif.  
**DIGITAL EQUIVALENT PSK RECEIVER TECHNIQUES**  
Francis D. Natali. In AGARD Aerospace Telecommun. Systems Aug 1972. 13 p. refs (For availability see N73-10187 01-07) (Contract F30602-69-C-0099)

All-digital techniques for receiving and coherently detecting moderate data rate (less than 1 Mbps) PSK signals in real time are discussed. A receiver employing synchronous bandpass sampling and A/D conversion of the IF signal is described. Synchronism, bit synchronization, and data detection are performed by a special-purpose digital processor. Analytical methods are developed for predicting receiver performance, and experimental data is presented to indicate the degree of agreement that one might expect. Author

**N73-10197** Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany).

**ADAPTIVE PRE-WHITENING FILTER**  
R. Klemm. In AGARD Aerospace Telecommun. Systems Aug 1972. 7 p. refs (For availability see N73-10187 01-07)

Some methods are shown for calculating the optimal linear pre-whitening filter function from real time computed correlation functions. The problem is due to the optimal detection of target signals in correlated noise in radar technique. In principle the received data are multiplied with the inverse of the correlation matrix of the noise, based on the Wiener theory, however, a linear function, that is, the first column of the inverse of the correlation matrix can also be given. Three methods are shown and discussed, by means of which it is possible to calculate the first column in real time without inverting the whole matrix. Author

**N73-10198** Mitre Corp., Bedford, Mass.  
**A FLEXIBLE HARDWIRED FAST FOURIER TRANSFORM DIGITAL PROCESSOR**  
E. A. Palo and G. C. O'Leary. In AGARD Aerospace Telecommun. Systems Aug 1972. 15 p. refs (For availability see N73-10187 01-07) (Contract F19628-71-C-0002)

A hardwired digital processor based on the Cooley-Tukey algorithm is presented. A laboratory prototype has been built with two modes of operation. As a cascade fast Fourier transformer, it can simultaneously calculate transforms of two independent, continuous data streams at word rates in excess of 3 MHz. As a nonrecursive digital filter, it can produce filter impulse responses of up to 32 points. The digital filter also operates from data sources with word rates exceeding 3 MHz. The processor has been integrated into a system with other signal processing components including a small general purpose computer. Laboratory demonstration of the processing system as a spectrum analyzer and as an adaptive filter for distortion correction is discussed. Author

**N73-10199** Siemens AG, Munich (West Germany).  
**THE ADAPTIVE EQUALIZATION OF TRANSMISSION SYSTEMS**

K. H. Moehrmann. In AGARD Aerospace Telecommun. Systems Aug 1972. 16 p. refs (For availability see N73-10187 01-07)

After a general introduction some of the principles of adaptive optimization are explained using as example the automatic identification of the transfer function of a linear system under operating conditions. Then several techniques for the automatic minimization of the linear distortions in communication channels

are discussed with emphasis on telephone channels for fast transmission of digital data. Some filter structures suited for this purpose are described together with several possible strategies to implement the settings of the variable filter elements automatically during a training period before information transmission or in an adaptive manner during transmission. Finally, after discussing the partial response technique and the equalization of digital data signals transmitted at high bit rates over long-haul coaxial carrier systems, some related applications of adaptive techniques are described concerning the equalization of long cable systems used for analog transmission of television signals, the equalization of FM/FDM radio relay systems due to elimination of intermodulation distortion and the adaptive cancellation of echoes in long distance telephone circuits. Author

**N73-10200** Rensselaer Polytechnic Inst., Troy, N.Y. Systems Engineering Div.  
**ADAPTIVE EQUALIZATION WITHOUT TEST TRANSMISSIONS**

Chia-Chi Chen and Lester A. Gerhart. In AGARD Aerospace Telecommun. Systems Aug 1972. 14 p. refs (For availability see N73-10187 01-07) (Contracts DAAB07-69-C-0365, AF 49(638)-1627)

An extended gradient method for iteratively solving sets of linear equations has been developed and used here as the algorithm to perform adaptive equalization. Although stress has been placed on using this algorithm without test transmissions, for transversal equalizers, the algorithm may also be used with test transmissions as well as for recursive equalizers. Initially, stationary, binary, bipolar channels are equalized without test signals. For highly dispersive channels, the algorithm uses a variable history of past sequences to provide more effective equalization. The algorithm, if used when test signals are available, permits channels to be equalized with multilevel signals transmitted instead of confining transmission to the binary, bipolar case. The algorithm has also been proven useful for adapting as equalizer in conjunction with a time varying channel because it can accommodate to rapidly varying characteristics. Author

**N73-10201** North Atlantic Treaty Organization, Bruxelles (Belgium).

**PROPAGATION CRITERIA WITH TACTICAL SATELLITE COMMUNICATIONS**

H. J. Albrecht, M. Eggestad, and L. A. Maynard. In AGARD Aerospace Telecommun. Systems Aug 1972. 13 p. refs (For availability see N73-10187 01-07)

Tactical satellite communications may use a variety of frequency bands depending upon the application. Considering mobility and simplicity of equipment some of the more important aspects, the UHF range was found to be particularly suitable. In other words, operating frequencies are within the 200 to 400 MHz portion of the spectrum. Propagation criteria considered are (1) scintillation effects due to ionospheric irregularities, (2) ray deviation caused by atmospheric layers, (3) multipath effects, and (4) transparency of surrounding materials. Scintillations are analyzed on the basis of experimental and theoretical results obtained. The subject of ray deviation is closely related to abnormal tropospheric conditions. With regard to multipath effects, the general aspects of ground reflections are analyzed for the purpose of evaluating their importance with mobile surface terminals. The problem of penetrating surrounding materials may be essential, whenever a porous obstacle, such as vegetation, is present in the path between surface terminal and satellite. Author

**N73-10202** North Atlantic Treaty Organization, Bruxelles (Belgium).

**SYSTEM CONSIDERATIONS IN TACTICAL SATELLITE COMMUNICATIONS**

H. J. Albrecht, R. Makruschka, and R. Menzel. In AGARD Aerospace Telecommun. Systems Aug 1972. 15 p. refs (For availability see N73-10187 01-07)

The use of wide band satellites with frequency conversion and hard limiting displays certain disadvantages and limitations, particularly if the bandwidth is restricted to, e.g., 500 kHz in

the UHF range. This causes the number of links to be limited if simultaneous operation is envisaged. Another possible system uses wide band satellites with adjustable characteristics, such as linear, quasi-linear, or hard limiter operation. Considering wide bandwidths of the order of 10 MHz in the UHF range, some advantages may be gained by such adjustable characteristics under jamming conditions. The vulnerability of the entire system can be reduced by single channel operation, employing satellites with separate channels covering the entire bandwidth of 10 MHz with multiple base band operation. Among the feasible combined systems are those using UHF and SHF. For tactical satellite systems, a possible configuration comprises a quantity of smaller terminals operating on UHF with a satellite receiving on UHF and retransmitting on SHF to a powerful master surface terminal, acting as net control and relaying the retransmitted signal on SHF to the satellite, which again establishes a UHF link to the desired smaller terminal. Author

**N73-10203** Shippe Air Defense Technical Center, The Hague (Netherlands)

**GROUND TERMINAL MEASUREMENT REQUIREMENTS WITH RESPECT TO SATELLITE COMMUNICATIONS LINK AVAILABILITY**

A. N. Ince and A. Wallrabe. In AGARD Aerospace Telecommun. Systems. Aug 1972. 12 p. refs. (For availability see N73-10187 01-07)

Communications satellite systems are considered with multiple ground terminals carrying many voice channels, linked to each other via a geostationary satellite. To obtain the required link capacities with specified performance it is necessary to set the levels of the assessing carriers very carefully to achieve the appropriate sharing of the satellite output power. The satellite system control center measures link parameters and instructs the ground terminals to adjust transmitter powers in order to counteract the performance degradation due to external factors. The accuracy with which the system parameters can be measured determines how well the carrier levels may be controlled and consequently the availability of the communication links. Measurement methods for some of the most important quantities are given and the accuracy achieved with an experimental satellite terminal is discussed. Author

**N73-10204** Admiralty Surface Weapons Establishment, Portsmouth (England)

**SCOT SATELLITE COMMUNICATION TERMINAL**

P. R. Lees. In AGARD Aerospace Telecommun. Systems. Aug 1972. 4 p. (For availability see N73-10187 01-07)

SCOT is the satellite communication terminal in production for the Royal Navy for installation in frigates and certain other classes of ships. It provides broadcast and ship-shore facilities within the SKYNET system. A brief description of the terminal and some of the problems of access and control related to the necessity to fully exploit the terminal's capability are reported. Author

**N73-10205\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

**FACTORS AFFECTING FREQUENCY AND ORBIT UTILIZATION BY HIGH POWER TRANSMISSION SATELLITE SYSTEMS**

Perry W. Kuhns, Edward Miller, and Thomas J. Malley. In AGARD Aerospace Telecommun. Systems. Aug 1972. 16 p. refs. (For availability see N73-10187 01-07)

The factors affecting the sharing of the geostationary orbit by high power (primarily television) satellite systems having the same or adjacent coverage areas and by satellites occupying the same orbit segment are examined and exemplified using the results of computer computations are given. The factors considered include required protection ratio, receiver antenna patterns, relative transmitter power, transmitter antenna patterns, satellite grouping, and coverage pattern overlap. The results presented indicate the limits of system characteristics and orbit deployment which can result from mixing systems. Author

**N73-10206** Royal Air Force, Marlow (England)  
**AUTOMATIC MESSAGE SWITCHING AND DATA TRAFFIC**

**HANDLING IN A MILITARY COMMUNICATIONS NETWORK**  
C. H. Blanchard. In AGARD Aerospace Telecommun. Systems. Aug 1972. 12 p. refs. (For availability see N73-10187 01-07)

Computer based message switching systems fulfill a necessary function within a military system, and it is expected that the size and complexity of these highly sophisticated systems will increase. Some of the problems associated with the design, procurement and maintenance of such systems are: Basic fact finding exercises, operational requirement, drafting of a procurement specification, and project definition and tender evaluation. Author

**N73-10207** Honeywell Information Systems, Inc., Tampa, Fla.

**THE AUTOMATED TECHNICAL CONTROL (ATEC) SYSTEM**

Louis Calden and Anthony S. Szolkowski (RADC N. Y.). In AGARD Aerospace Telecommun. Systems. Aug 1972. 18 p. refs. (For availability see N73-10187 01-07)

The ATEC system assigns functions to men and machines so that each does most that which they do best. In general, this means machine tasks include the collection, processing, sorting and retrieving of data under the direction of the man whose function includes reasoning, deciding, interpreting, controlling and directing. The overall ATEC design philosophy provides bidirectional modularity for customization to the communication station and graceful degradation in case of failure. Therefore, the total system capability is never lost by failures of even considerable portions of the ATEC. The concept, structure and application of the ATEC system and its subelements are described. Author

**N73-10208** Air Force Communications Service, Richards-Gebaur AFB, Mo.

**THE TRANSMISSION PERFORMANCE OF THE DEFENSE COMMUNICATIONS SYSTEM**

Yuen-sun Fu and Robert L. Ffuk. In AGARD Aerospace Telecommun. Systems. Aug 1972. 9 p. refs. (For availability see N73-10187 01-07)

A system wide measurement program on the defense communications system was initiated in 1967. The sample plan and measurement procedures are discussed briefly. A summary of the analysis results is presented. It contains estimates of population means for frequency response, delay distortion, impulse noise, idle channel noise and harmonic distortion for the voice channels within the defense communications system. Finally, the 90 percent confidence interval as well as estimates of standard deviation are computed. Author

**N73-10209** Electronic Systems Div., L. G. Hanscom Field, Mass.  
**DIGITAL VERSUS ANALOG COMMUNICATIONS SYSTEMS: TECHNICAL AND ECONOMIC CONSIDERATIONS**

Carl A. Segerstrom. In AGARD Aerospace Telecommun. Systems. Aug 1972. 10 p. (For availability see N73-10187 01-07)

The limitations of the current world wide analog transmission plant is viewed in terms of its data and voice handling capability. In addition, improved data transmission is highlighted using microwave, cable or tropo. when using digital rather than analog techniques in optimizing information flow. Some of the system improvements expected in using digital switching techniques and the increased possibilities for the inclusion of technical control in the switch designs are discussed from a system viewpoint. Since the current plant represents a large investment and outright replacement of an entire network is impractical, the process of hybridization and eventual all digital implementation over a 20-30 year interval is examined. Finally some of the possible overall improved system characteristics are listed that cannot now be achieved in the present analog configuration. Author

**N73-10210** Lear Siegler, Inc., Grand Rapids, Mich., Instrument Div.

**KALMAN FILTERING FOR RAPID AND ACCURATE DETECTION OF CW INTERFERENCE ON DIGITAL TELECOMMUNICATIONS**

R. J. Fredericks. In AGARD Aerospace Telecommun. Systems. Aug 1972. 24 p. refs. (For availability see N73-10187 01-07)

Application of the quasi-linear Kalman filtering algorithm to the problem of estimating the frequency, amplitude and, if desired,



initial phase of one or more interfering CW signals is described. These unwanted sinusoids are assumed present in a background of noise and the useful signal bandwidth is assumed to be 20-26 kHz with the jammer(s) located anywhere in this spectral interval. Channel center frequencies located throughout the range 100 kHz to 1000 GHz are investigated without requiring any changes in the basic filter structure. While the state dynamics are linear the measurements are highly non-linear functions of the state variables. Because of the non-linearity in the measurements and the fact that the measurement noise is nonwhite various techniques such as the addition of a fourth variable with the dimensions of hertz to the state vector and the use of an adaptive measurement noise matrix are required to insure proper filter convergence. Results are given showing filter operation with J/N ratios from -9db upwards to over +20db. Typical frequency estimation errors after 1000-2000 microseconds with high J/N ratios are on the order of 10 Hz. Author

**N73-10211** Post Office Research Dept., Ipswich (England)  
**THE EFFECT OF INTERCHANNEL INTERFERENCE ON THE PERFORMANCE OF A PHASE MODULATED DIGITAL SYSTEM**

M. C. Davies. In AGARD Aerospace Telecommun. Systems. Aug 1972. 17 p. (For availability see N73-10187 01-07)

Computer programs employing simulation and analytical techniques were developed for calculating the error performance of 2- and 4-level coherent-phase-shift keyed (CPSK) and differential-coherent-phase-shift keyed (DCPSK) systems containing filters of specified characteristics. The effect of these filters on the distortion in the wanted channel, and on the probability density and magnitude of the interference were taken into account. Some preliminary 2-level CPSK results from a versatile experimental test facility are in good agreement with the corresponding theoretical results. Author

**N73-10212** Southampton Univ. (England). Dept. of Electronics  
**GENERATION OF INTERMODULATION INTERFERENCE DUE TO NON-LINEAR EFFECTS IN THE NEAR FIELD REGIONS OF MULTIPLE TRANSMISSION COMMUNICATION SYSTEM**

J. A. Belts and D. R. Ebenezer. In AGARD Aerospace Telecommun. Systems. Aug 1972. 12 p. refs. (For availability see N73-10187 01-07)

The co-location of transmitters and receivers for military mobile requirements, particularly when a multiple-frequency transmission capability is essential, produces a serious problem of intermodulation interference. The results of a laboratory investigation in which steel specimens have been subjected to two-frequency excitation (mainly in the HF range at 1.2 and 5.1 MHz) of known field strength and orientation are described. Particular attention has been given to the intermodulation level dependence upon surface preparation, which includes machined and polished, serrated, electrodeposited cadmium and cold-sprayed zinc finishes. Results are also described for stainless alloy and carbon steels. The effect of surface corrosion, which has hitherto been referred to as the rusty-bolt problem, is also described and its effect within an active transmission system has been distinguished from that on parasitic surfaces. Author

**N73-10213** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)  
**DIRECTIONAL ANTENNAS FOR A NEW INTERFEROMETER SYSTEM (SIDELOBE SUPPRESSION, PHASE CHARACTERISTICS, SUPPRESSION OF GROUND REFLECTIONS)**  
 H. Oertli and H. Goessl. In AGARD Aerospace Telecommun. Systems. Aug 1972. 8 p. refs. (For availability see N73-10187 01-07)

A new interferometer system with antennas mounted on E/Az-pedestals is considered. Each antenna consists of an array of 36 crossed dipoles. There is a Tchebyscheff amplitude distribution in the elevation plane and in the plane orthogonal to it. Since the distance between the three interferometer antennas is 57 lambda, the suppression of reflected signals must be better than 40 to 50 db to keep the phase error due to reflections in the order of 0.1 deg. A further method of suppressing

ground reflections, i.e. the use of concentric wire-mesh fences around each antenna, is also mentioned. Another error of the antenna system is the phase pattern discrepancies between

**N73-14131#** Advisory Group for Aerospace Research and Development, Paris (France)  
**EFFECTS OF ATMOSPHERIC ACOUSTIC GRAVITY WAVES ON ELECTROMAGNETIC WAVE PROPAGATION**  
 Oct 1972. 508 p. refs. In ENGLISH, partly in FRENCH. Presented at Specialist Meeting of the Electromagnetic Wave Propagation Panel of AGARD, Wiesbaden, 17-21 Apr 1972. (AGARD-CP-115). Avail. NTIS HC \$27.50

The generation, propagation, and effects of acoustic gravity waves on atmospheric transmission of electromagnetic waves are discussed. The formation of traveling ionospheric disturbances and their influence on radioelectric communications are emphasized. For individual titles, see N73-14132 through N73-14170

**N73-14132** National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab.  
**SOME ANALOGIES BETWEEN THE PROPAGATION OF IONOSPHERIC RADIO WAVES AND ACOUSTIC GRAVITY WAVES**

Kenneth Davies. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 12 p. refs. (For availability see N73-14131 05-07)

The propagation of radio waves in the ionosphere is similar to that of acoustic gravity waves in the neutral atmosphere. Both are anisotropic and dispersive. Furthermore, the temperature structure in the atmosphere is somewhat similar to the electron density structure in the ionosphere. Ray tracing of acoustic waves exhibit high- and low-angle rays, skip zones, etc. Author

**N73-14133** National Oceanic and Atmospheric Administration, Boulder, Colo. Wave Propagation Lab.  
**A 3D TRACING FOR ACOUSTIC GRAVITY WAVES**

T. M. Georges. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 10 p. refs. (For availability see N73-14131 05-07)

A new general purpose ray tracing program for acoustic gravity waves has been developed. It allows atmospheric wind and temperature to vary in all three spatial dimensions and with time and accounts for earth curvature. Ray plots show the characteristic acoustic ray patterns of a standard atmosphere but also some interesting and unexpected ray geometries in cases of more complex wind fields and for internal gravity waves. Author

**N73-14134** National Bureau of Standards, Washington, D.C.  
**GENERATION AND PROPAGATION OF SOUND WAVES BETWEEN THE IONOSPHERE AND THE LOWER ATMOSPHERE**

Richard K. Cook. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 8 p. refs. (For availability see N73-14131 05-07)

Various physical processes generate sound waves at infrasonic frequencies in the lower atmosphere. The results of an analysis for the generation of sound and propagation downwards due to the heating effects of auroral discharges, particularly those traveling at supersonic speeds in directions parallel to the earth's surface are presented. The shock waves from such discharges are propagated steeply downward with very little loss of energy from absorption by viscosity and heat conduction, and are frequently observed at infrasonic stations located at high latitudes. An estimate of auroral heating is derived from the observed strengths of infrasound at the earth's surface. Author

**N73-14135** Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering  
**A MODEL FOR ACOUSTIC GRAVITY WAVE EXCITATION BY BUOYANTLY RISING AND OSCILLATING AIR MASSES**

Allan D. Pierce. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972.

12 p. refs (For availability see N73-14131 05-07)  
(Contract F19628-70-C-0008)

A somewhat general mathematical model is developed for the study of the excitation of acoustic-gravity waves by rising and oscillating air masses. Sources are initially described by distributions of fluid dynamic quantities over a moving closed surface. Analysis then indicates that insofar as wave generation is concerned, such surface distributions are equivalent to concentrated point sources at the center of the volume. The resulting linearized inhomogeneous wave equations are derived and solved in terms of Green's functions. The case of an isothermal atmosphere is discussed in some detail. Author

**N73-14136** Imperial Coll. of Science and Technology, London (England)

**ACOUSTIC GRAVITY WAVES AND DIFFUSION EFFECTS AT THE ATMOSPHERIC BOUNDARIES**

F. W. G. Warren. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct. 1972. 8 p. refs (For availability see N73-14131 05-07)

The boundary conditions in the linear theory of acoustic gravity waves in the atmosphere are discussed. It is shown that diffusion effects at the boundaries may for the most part be ignored provided the vertical wave number is not too small. The results for gravity waves agree qualitatively with those obtained by Yanowitch (1967) but the details differ. An upper bound for the reflection coefficient for small vertical wave numbers is obtained. It is recalled that the results hold only if the mean free path at high altitudes is small compared with the horizontal wavelength. Author

**N73-14137** Alaska Univ. College. Geophysical Inst.  
**AURORAL INFRASONIC WAVE GENERATION MECHANISM**

Charles R. Wilson. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct. 1972. 20 p. refs. Sponsored in part by ARPA and NOAA (For availability see N73-14131 05-07)  
(Grant NSF GA-16821)

The morphology of auroral infrasonic wave (AIW) substorms as determined from infrasonic observations along a magnetic meridian through Alaska, shows that AIW are never observed propagating in a poleward direction even though auroral activity frequently occurred south of the stations. AIW have been shown to be infrasonic bow waves generated by supersonic westward, equatorward or eastward motions of auroral electrojet arcs. This asymmetry in the occurrence of AIW with respect to direction of motion of an arc is interpreted as an intrinsic asymmetry in the generation mechanism within the auroral arcs and not as a propagation effect. It is postulated that the basic acoustic pulse within the electrojet arcs is caused by collisions with the neutral gas of positive ions that are driven by electrodynamic drift in the E region of the auroral arc. If the supersonic translation of the primary auroral electron sheet has a component of motion parallel to the electrodynamic drift of the positive ions, then an auroral infrasonic shock wave will be produced in the E region ionosphere and propagate to the ground as a modified shock or bow wave. If, on the other hand, the auroral arc motion is anti-parallel to the drift of the positive ions, then no AIW will be produced. Author

**N73-14138** Kiruna Geophysical Observatory (Sweden)  
**DETECTION OF 2 HZ INFRASOUND PRODUCED BY MOVING AURORAL ELECTROJETS**

Ludwik Liszka and Hans Westin. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct. 1972. 12 p. refs (For availability see N73-14131 05-07)

Two Hz infrasound was detected during a number of major geomagnetic storms using microphone arrays. The direction of arrival and the horizontal phase velocity of the infrasound at the microphone arrays were obtained. These quantities were compared with motions of the auroral electrojet as determined from geomagnetic observations at five Scandinavian stations. The comparison, using a ray tracing technique, has shown that only a part of the observed infrasound may be produced by supersonic motions of auroral electrojets. Author

**N73-14139** Illinois Univ. Urbana. Ionosphere Radio Lab.  
**ON WAVES GENERATED BY STATIONARY AND TRAVELING SOURCES IN AN ISOTHERMAL ATMOSPHERE UNDER GRAVITY**

C. H. Liu and K. C. Yeh. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct. 1972. 17 p. refs (For availability see N73-14131 05-07)  
(Grant NSF GA 13723)

Experimental evidence indicates that acoustic gravity waves in the neutral atmosphere can be generated by various natural and artificial sources such as earthquakes, severe weather fronts, nuclear detonations in the atmosphere, jet streams, supersonic displacements of auroral arcs, auroral substorms, solar eclipses, jet aircrafts, rocket launchings, etc. These various excitation mechanisms can be considered as one or a combination of the three types of sources: mass production, momentum production and energy production which can be studied in a very general fashion. For the case of stationary sources, it is shown that the transient response and the overall wave form at a given observation point depend on a number of parameters such as the height and the range of the observation point, the time of observation, the spatial and temporal dependence of the source, the nature of source, etc. Author

**N73-14140** Lamont-Doherty Geological Observatory, Palisades, NY

**ACOUSTIC GRAVITY WAVES IN THE NEUTRAL ATMOSPHERE AND THE IONOSPHERE**

Ramabath K. Balachandran. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct. 1972. 11 p. refs (For availability see N73-14131 05-07)  
(Contract DAAB07-69-C-0256. Grants DA AR0(D-31-124-71-G90. NSF GA 17454)  
(Contrib. 1799)

Acoustic gravity waves from nuclear explosions are detected at large distances from the source by sensitive microbarograph on the ground by high frequency Doppler technique at ionospheric levels and by long period seismographs. The dispersion of acoustic gravity waves at the ground level is explained by using normal mode approach for a stratified atmosphere. For acoustic gravity waves detected at the ground level, the short period acoustic modes have higher amplitudes than the long period gravity modes when stratospheric winds are in the direction of propagation of the waves. Doppler mode records of ionospheric disturbances show more predominance of shorter period acoustic modes than the gravity modes. According to the normal mode theory and the Lamb wave theory, the energy density for long period waves decreases exponentially with height from the ground, thus providing insufficient energy for ionospheric disturbances. Author

**N73-14141** Mount Auburn Research Associates, Inc., Newton, Upper Falls, Mass.

**MODELING OF NUCLEAR SOURCES OF ACOUSTIC GRAVITY WAVES**

Brian L. Murphy and Sheldon L. Kahalas. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct. 1972. 17 p. refs (For availability see N73-14131 05-07)  
(Contract 144620-71-C-0086)

The relationship between hydrodynamic motions caused by a low altitude explosion and subsequent ionospheric disturbances is reviewed. Both the upward going shock and the rising fireball are considered as hydrodynamic sources. It is shown that different portions of the shock front may be classified in terms of the ionospheric disturbance they create. The portion of the shock front reflected from the 100-120 km altitude level produces disturbance periods the order of a minute for a megaton detonation. The portion of the shock front which propagates above the 100-120 km level is responsible, through a complex nonlinear process, for disturbance periods in excess of 10 minutes. It is shown that the fireball is most efficient in generating acoustic gravity waves when it reaches its stabilization altitude and approaches hydrodynamic equilibrium with the atmosphere. Author

N73-14142 Ecole Normale Supérieure, Paris (France) Lab de Physique

# THE THEORY OF ATMOSPHERIC ACOUSTIC PROPAGATION

Ch Berthel and Y. Rocard. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 18 p. In FRENCH. ENGLISH summary (For availability see N73-14131 05-07)

A comprehensive review of atmospheric acoustic wave propagation is reported. Calculations demonstrate the radiating properties of the infrasonic noise ring created by large explosions on the ground in directions other than those of the rays which formed it. Introduction of nonlinearity in the propagation of infrasonic short period waves results in the bending of acoustic rays back to the ground. Author

# N73-14143 Massachusetts Inst of Tech, Cambridge EXPLOSIVE EXCITATION OF LAMB'S ATMOSPHERIC EDGE MODE

Joe W. Posey and Allan D. Pierce. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 12 p. refs (For availability see N73-14131 05-07)  
(Contract F19628 70 C 0008)

It has been previously demonstrated that far field ground level pressure observations of explosively generated acoustic gravity waves are often dominated by the Lamb atmospheric edge mode for the first cycle or two. Particular attention is given to the excitation of this mode by a blast wave from a large atmospheric explosion. It is found that the strength of the excitation is strongly dependent upon the tail of the blast wave. A theoretical development shows that for the pure Lamb mode, a simple analytical relation exists between the energy of the source and the initial amplitude and period of the far field pressure waveform. This relation is compared with some empirical data and appears to be in fair agreement with field estimates based on seismic observations. Author

# N73-14144 Stanford Research Inst, Menlo Park, Calif JUSTIFICATION FOR THE USE OF HINES' ASYMPTOTIC RELATIONS FOR TRAVELING IONOSPHERIC DISTURBANCES

Norman J. F. Chang. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 10 p. refs (For availability see N73-14131 05-07)

It is shown that internal gravity waves propagating at ionospheric heights must have propagation angles near the maximum permitted. Thus, for traveling ionospheric disturbances (TIDs) the use of Hines' asymptotic relations is justified by ray tracing. Verification of these relations is made by comparison of theoretical with experimental results for fifteen TIDs. The effects of the temperature profile on the measurable properties of TIDs (wavefront tilt and period) are discussed. It is shown that for TIDs that originate below the mesopause, the atmosphere behaves like a bandpass filter with center frequency favoring waves with periods near 20 minutes. Author

# N73-14145 Max Planck Institut fuer Aeronomie, Lindau, Ober Nordheim (West Germany) Inst fuer Ionosphaerenphysik FULL WAVE CALCULATIONS OF ELECTRON DENSITY PERTURBATIONS CAUSED BY ATMOSPHERIC GRAVITY WAVES IN THE F2 LAYER

J. Klostermeyer. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 11 p. refs (For availability see N73-14131 05-07)

The coupled system of hydrodynamic equations which describes gravity wave perturbations in the neutral and ion gases is solved by a full wave method including the effects of height dependent temperature and winds, Coriolis force, viscosity, thermal conduction, and ion drag. Calculated results agree well with experimental data deduced from vertical incidence ionograms. The numerical calculations are further combined with observed gravity wave parameters to obtain height profiles of the amplitude and phase of the electron density perturbation as functions of the geomagnetic inclination and the azimuth of wave propaga-

tion. The calculated perturbation depends very strongly on height, inclination, and azimuth. Its amplitude varies between 0 and 100 per cent of the undisturbed electron density, and its phase may change rapidly around the F-layer maximum. Author

N73-14146 Queensland Univ., Brisbane (Australia) Dept of Physics

# ATMOSPHERIC PRESSURE WAVES AT BRISBANE AND THEIR ASSOCIATION WITH CERTAIN IONOSPHERIC AND SOLAR EVENTS

G. G. Bowman. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 13 p. refs (For availability see N73-14131 05-07)

Two aspects of the nighttime recordings, at Brisbane, of microbarographs of high sensitivity are examined when the records showed well defined gravity waves with periods around 12 minutes and amplitudes of the order of 10 microbar. Superposed epoch analyses using these occurrences as control dates, for a sunspot minimum period, revealed an apparent association between the dates and the occurrence of ionospheric spread F conditions in subauroral regions of the earth. Also when sunspot activity and geomagnetic activity were plotted relative to these dates, there was evidence of 27 day periodicities in the distributions. Some gravity wave occurrences are shown to be related to the passage of weather fronts at Brisbane. However, it is the remaining occurrences which appear to be associated with the occurrence of spread F. Some evidence for an association between the occurrence of atmospheric acoustic waves and sunspot activity is developed. Author

N73-14147 National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab

# FURTHER REMARKS ABOUT TRAVELING IONOSPHERIC DISTURBANCES ATTRIBUTED TO JET STREAM ACTIVITY AT MID-LATITUDE

G. B. Goe. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 13 p. refs (For availability see N73-14131 05-07)

Medium scale traveling ionospheric disturbances with periods of 12 to 30 minutes are detected during daytime winter at F region heights. These disturbances are present when it is magnetically quiet and are attributed to the presence of active wind patterns associated with the jet stream at the height of the tropopause. The active patterns on the tropopause wind analysis maps are recognized by horizontal wind shear as the direction of flow lies parallel to the isolines of constant wind speed. The activity diminishes as the wind accelerates or decelerates in the direction of flow. The ionospheric activity resulting from these active tropopause winds may be thought of as localized in terms of global circulation and hence is neither observed nor predicted on a global scale. This is unfortunate as HF radio transmission is affected by the presence of such ionospheric disturbances. Author

# N73-14148 Massachusetts Inst of Tech, Cambridge GENERATION OF ANOMALOUS IONOSPHERIC OSCILLA- TION BY THUNDERSTORMS

C. A. Moo and A. D. Pierce. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 8 p. refs (For availability see N73-14131 05-07)  
(Contract F19628 70 C 0008)

Radio HF Doppler sounding of the ionosphere shows oscillations during periods of thunderstorm activity. These oscillations have periods in the range of 2 min to 5 min, frequently for many hours duration. The coherence of the oscillations is consistent with the interpretation generally given that they are caused by the passage of long wavelength infrasonic waves. There are apparently no similar distinct oscillations with the same period range associated with air motion in the troposphere during severe weather. However, convective activity is known to generate fluctuations and internal waves with periods near and above Brunt-Vaisala periods. A theory for the generation of these ionospheric 2 to 5 min period waves, based on concepts similar to those used by Lighthill in the theory of aerodynamic sound is proposed. Author

**N73-14149** Max-Planck Institut fuer Aeronomie, Lindau Ober Northerm (West Germany)

**A PHENOMENOLOGICAL INVESTIGATION OF AMPLITUDES AND SPECTRA OF GRAVITY WAVES**

J. P. Schoedel. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 13 p. refs. (For availability see N73 14131 05 07)

Observations of the ionospheric electron content by means of geostationary beacon satellites very often exhibit oscillations of sinusoidal form. Faraday rotation records represent a good monitoring system for these oscillations. For the investigation of the oscillations the records of the electron content were filtered numerically. The amplitudes of effects caused by gravity waves can easily be demonstrated after the filtering. The filtered part of the data - representing the wave induced fluctuations - can be used for the computation of power spectra. The following facts are found: (1) The wave amplitude decreases rapidly with decreasing period length; (2) all periods can be observed; and (3) harmonic frequencies are usually not observed. Author

**N73-14150** Stanford Research Inst., Menlo Park, Calif. Radio Physics Lab

**COMPARISON OF COMPUTED AND OBSERVED SHOCK BEHAVIOR FROM MULTIKILOTON, NEAR SURFACE NUCLEAR EXPLOSIONS**

Demetri P. Kanellakos and Raymond A. Nelson. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 16 p. refs. (For availability see N73-14131 05 07)

(Contracts F33657 68 C 1147, F33657 70 C 0090)

Comparisons are made between numerical hydrodynamic calculations of the propagation through the ionosphere of shock fronts arising from near surface nuclear explosions and experimental observations of the ionospheric disturbances associated with these shock fronts. The purpose of these comparisons is to provide a test of the validity of numerical hydrodynamic calculations at ionospheric heights. Experimental values obtained from ionograms taken for some nuclear test series clearly show an acceleration of the shock front at altitudes above 100 km. There is agreement between experimental and calculated values to within a few km for the primary shock front in spite of a lack of knowledge of the exact atmospheric parameters at the times of the tests. Author

**N73-14151** National Oceanic and Atmospheric Administration, Boulder, Colo. Wave Propagation Lab

**FM CW RADAR STUDIES OF PRODUCTION OF TURBULENT INSTABILITY WITHIN THERMALLY STABLE LAYERS BY INTERNAL WAVES**

Earl E. Gossard and J. H. Richter (Naval Electron Lab. Center). In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 16 p. refs. (For availability see N73 14131 05 07)

A recent development in radar sounding has made the detailed structure of the troposphere visible to a degree previously not approachable. The radar sounder is an FM CW system. The most outstanding features evident in the records are internal gravity waves, features resembling Kelvin-Helmholtz instability structures, multiple layering often displaying lamina only a few meters thick, and convection cells within the marine layer. A variety of atmospheric structural patterns are shown and compared with several hypothetical models of internal wave structures to obtain more insight into the atmospheric processes at work. Special attention is given to the distribution of Richardson's number in trapped and untrapped gravity waves. It is concluded that the multiple layers result from untrapped internal gravity waves whose propagation vector is directed nearly vertically within very stable height regions. Author

**N73-14152** Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.

**THE DETECTION AND STUDY OF GRAVITY WAVES WITH MICROWAVE RADAR**

Isadore Katz. In AGARD Effects of Atmospheric Acoustic Gravity

Waves on Electromagnetic Wave Propagation. Oct 1972. 11 p. refs. Sponsored in part by AFCL (For availability see N73 14131 05 07)

The use of ultra sensitive radars has resulted in a new ability to see structure and motion of the atmosphere not possible before. Among other things these radars detected gravity waves at the tropopause. Experimental proof has been obtained which shows incontrovertible evidence that Bragg scattering is the prime cause of the electromagnetic scattering phenomenon. The signal strength of the radar echoes was found to be a linear function of the spectral density of refractive index fluctuations in the atmosphere. A review of 28 gravity wave cases permits a tentative characterization of these waves in terms of sizes, shapes, persistence and conditions under which they occur. Author

**N73-14153** Politecnico di Torino (Italy). Ist. di Elettronica e Telecomunicazioni

**OBSERVATIONS OF GRAVITY WAVES IN THE HEIGHT RANGE**

G. E. Perona. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 10 p. refs. (For availability see N73-14131 05 07)

Acoustic gravity waves can successfully be detected in the D region of the ionosphere in spite of all the well known difficulties that characterize the interpretation of the data concerning that region. This possibility is demonstrated from a theoretic point of view and is successively confirmed by a careful analysis of VLF data and cross modulation data, related to the 50-70 km range. The limits on the amplitude, frequency and wavelength of acoustic gravity waves that may be detected at these levels, are outlined. Author

**N73-14154** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

**OBSERVATIONS OF GRAVITY WAVES IN THE HIGHER ATMOSPHERE BY MEANS OF METEOR TRAIN DETECTION**

M. Glass (Lab. de Phys. de l'Ecole Normale Supérieure), A. Spizzichino, and I. Revah. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 16 p. refs. In FRENCH, ENGLISH summary. (For availability see N73-14131 05 07)

Over 1000 individual values of neutral wind can be obtained daily, within the 75-105 altitude range, with a meteor radar. Data processing and harmonic analysis significantly exhibit progressive waves whose vertical propagation can be tracked owing to the accuracy in location due to the radar. The length of the measurement period (10 days) makes it possible to acquire data on the life duration of the gravity waves observed. Returns from ionized traces produced by meteorites penetrating into the higher atmosphere are also obtained. The radar is extremely sensitive and therefore can detect over 1000 meteor echoes daily. Owing to a novel device for measuring the distance between the radar and the meteor echo, and to the accurate determination of the elevation and azimuth of this echo, the altitude can be determined within  $\pm$  or  $\pm$  500 meters. The motions of the east-west component of the neutral wind within the 75-105 altitude range can be deduced from the Doppler effects on these echoes. Waves are thus exhibited whose vertical propagation can be tracked since the altitude is known. Besides tidal motions, with periods ranging from 12 to 24 hours and over, shorter period oscillations are observed which can be compared to gravity waves. Author

**N73-14155** Alaska Univ., College. Geophysical Inst. **NARROW BEAM HF RADAR INVESTIGATIONS OF MIDLATITUDE IONOSPHERIC STRUCTURE AND MOTION**

Robert D. Hunsucker. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 14 p. refs. (For availability see N73 14131 05 07)

Data acquired from 1964-1968 with a narrow-beam azimuth and elevation scan high frequency backscatter sounder have been analyzed in detail. This analysis has revealed that the irregular structure of the midlatitude ionosphere is the rule rather than

the exception irregularities of varying scale size and apparent motion were present in about 90% of the observations. The signatures observed by this HF radar system have been categorized into eight generic types which have been labelled with names roughly describing their appearance on the range-azimuth scan record. The relative diurnal and seasonal occurrence as well as the qualitative sunspot cycle and geomagnetic correlation of these signatures are presented. One particular type of signature was analyzed using a three dimensional computer ray tracing technique utilizing experimental data to modify an atmospheric gravity wave disturbance model. The synthetic backscatter record was sufficiently similar to the experimental HF radar record to justify this approach in the interpretation of backscatter data.

Author

**N73-14156** Centro Radioelettrico Sperimentale G. Marconi, Rome (Italy)

# **AN IMPORTANT CHARACTERISTIC OF SOME TRAVELLING IONOSPHERIC DISTURBANCES**

I. Ranzani and P. Giorgi. *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 2 p. refs. (For availability see N73-14131-05-07)

The observation of the F2 region winter TIDs by means of vertical sounding on a fixed frequency, showed that the occurrence time of some TID groups anticipates from day to day.

Author

# **N73-14167\* Alabama Univ. Research Inst. Huntsville. IONOSPHERIC DISTURBANCES CAUSED BY LONG PERIOD SOUND WAVES GENERATED BY SATURN-APOLLO LAUNCHES**

Ganti L. Rao. *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 11 p. refs. (For availability see N73-14131-05-07). (Contract NAS8-27088)

Wave-like disturbances were observed in the ionosphere following several nuclear explosions in early 1960's. Supersonic shock waves within the atmosphere generated by large rockets can cause ionospheric electron density perturbations. A CW phase path Doppler array in the New York area was operated during the Saturn Apollo 12 and 13 launches and recorded Doppler frequency fluctuations due to rocket launchings. Cross correlation and power spectral analyses of the phase path Doppler frequency variation records showed that the phase velocities of the signal arrivals were from south of the array with 700

800 m/sec corresponding to periods in the range of 2 to 4 minutes. Ionograms taken every 60 seconds from Wallops Islands showed clearly ionospheric disturbances due to rockets. The group velocities were estimated to be of the order of 450 m/sec. 1 obtained from the earliest visible disturbances seen on CW phase path Doppler records and ionograms together with the rocket trajectory data.

Author

**N73-14158** Communications Research Centre, Ottawa (Ontario), Dept. of Communications

# **OBSERVATIONS OF TRAVELLING IONOSPHERIC DISTURBANCES AT LONDON, CANADA**

J. Litva. *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 23 p. refs. (For availability see N73-14131-05-07)

Observations of travelling ionospheric disturbances were obtained by way of a new technique which is described in detail, namely measurement of angle of arrival and amplitude variations of radio waves which propagated through the ionosphere from localized regions of enhanced emission on the solar disk. The observations reported here show good evidence of TID wave trains consisting of 15 to 18 wave cycles. The angular deflections of the solar line of sight at 51.7 MHz were measured to be between plus or minus 6 to plus or minus 20 minutes of arc from which electron number density perturbations are calculated to be of the order of 1 to 2 percent. The observed variations in amplitude corresponding to the larger angle of arrival scintillations were about 5 db. The TIDs were primarily of two types, one with a period of approximately 6 minutes, the other with a period of 21 minutes. The former travelled with the speed of about 200 km/hr and a corresponding wave length of 20 km. The speed of the latter was between 800 and 2000 km/hr and

the corresponding wavelength between 300 and 700 km. They also had a preferred line of travel which was orientated north-south.

Author

**N73-14159** Government Communications Hq. Cheltenham (England)

# **THE EFFECT OF IONOSPHERIC DISTURBANCES ON THE BEARINGS OF INCOMING SKY WAVES**

A. O. Morgan. *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 19 p. refs. (For availability see N73-14131-05-07)

A series of experiments was conducted to examine the effects of TIDs on bearing measurements. The receiving aerial used was a circularly disposed wide aperture array and the output from the array was processed by an automatic bearing measuring equipment. The results showed that the bearing fluctuated with periods of the order of 20 minutes. On some days, the bearing record showed a continuous sequence of these fluctuations whereas on other days, the fluctuations were almost absent. On the assumption of a mirror type of reflection, the observed bearing error for a single hop path corresponded to ionospheric tilts of up to 9 degrees. Further, on this assumption, it is estimated that these tilts can change at the rate of up to one degree per minute. The results also suggest the presence of systematic tilts in the ionosphere, which change with the diurnal change of the solar zenith angle. The implications of these results, on practical radio communication, are briefly discussed.

Author

**N73-14160** Weapons Research Establishment, Salisbury (Australia)

# **IONOSPHERIC TILT MEASUREMENTS NEAR THE MAGNETIC DIP EQUATOR**

R. F. Trehan. *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 13 p. refs. (For availability see N73-14131-05-07)

Observations of ionospheric tilt have been made near the magnetic dip equator. During the daytime these observations were hindered by the continuous presence of the intense irregularities in the E region but the observed tilts appeared to be larger and to have a systematic tilt not seen in temperate latitudes. The bias was to the east during the daytime and reversed in direction at sunset during the equinoctial months. During the evening, if spread F was absent, the tilts of the F region could be observed more clearly. These evening tilts were of much greater magnitude, had a much longer time scale than in temperate latitudes, and had superposed faster variations of a smaller scale which might be attributed to gravity waves. Three nights of observations are available: one in winter, two in summer. In all three cases the maximum tilt (9 degrees) occurred near 2100 hours local time, the time normally associated with the equatorial rise in h'F after sunset, but in the first case (winter) the direction was north, whereas in the second (summer) it was west and in the third (also summer) it was east.

Author

# **N73-14161 Kiruna Geophysical Observatory (Sweden). ON THE GENERATION AND DETECTION OF ARTIFICIAL ATMOSPHERIC WAVES**

Ludwik Listka and Sixten Olsson. *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 11 p. refs. (For availability see N73-14131-05-07)

Preliminary results of detection of atmospheric waves produced by focussing of shocks generated by supersonic aircraft are presented. The flight trajectories were chosen so that the acoustic gravity waves following the shock front were focussed on the ground after reflection from the stratosphere or in the E layer. Infra-acoustic waves were detected on the ground using a 2 Hz infra-acoustic correlator. At the E layer the waves were detected using a modified vertical sounding technique. Results obtained during 11 test flights have shown that the ray tracing technique may be successfully used for predicting the propagation of atmospheric waves following shock fronts.

Author

# **N73-14162 Northeastern Univ. Boston, Mass. AN APPROACH TO THE ANALYSIS OF COUPLING**

**BETWEEN ACOUSTIC GRAVITY WAVES AND ELECTROMAGNETIC WAVES**

H R Reemer. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 12 p. refs. (For availability see N73-14131 05-07)

The development of theoretical models for plasma media whose parameters are spatially variable, and the use of these models to study wave propagation in such media with the aid of high speed computers is reported. Some of these theoretical models can be used to study the first-order effects of a low frequency wave disturbance (e.g. an acoustic gravity wave at a fraction of a Hertz) on a high frequency electromagnetic wave (at kilohertz or megahertz) propagating in the ionosphere. The formulation of the model and its adaptation to the problem of interest via perturbation theory are first described, followed by a general outline of the way in which this theory can be used to calculate the first order effects of the acoustic gravity wave on the electromagnetic wave. Some communication systems implications of this theory are briefly discussed at the end of the paper. Author

**N73-14165** Weapons Research Establishment, Salisbury (Australia)

**HF RAY TRACING OF GRAVITY WAVE PERTURBED IONOSPHERIC PROFILES**

P L George. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 17 p. refs. (For availability see N73-14131 05-07)

The results of a computer simulation of the direction of arrival of short range ionospheric radio ray paths in the presence of a medium scale travelling ionospheric disturbance (TID) are reported. The analytical representation of the TID is based both on actual observations of such disturbances and upon the theory of internal atmospheric gravity waves. Computed results of the time dependence of direction of arrival and Doppler shift, such as would be observed at a ground based station, show good qualitative agreement with observations. The relationship between the computed direction of arrival variations and certain characteristics of the TID model that produced them is examined at a low latitude and at a high latitude location. The accuracy of a simple geometrical model that has been proposed for tilt correction of apparent direction of arrival is evaluated. It is shown how the uncertain results derived from use of this model may be substantially improved by taking into account the direction of travel, velocity and scale of the TID, these parameters being derived by continuous observation at spaced stations. Author

**N73-14164** Max-Planck-Institut fuer Aeronomie, Lindau Ober Northeim (West Germany)

**SOME EFFECTS OF ATMOSPHERIC GRAVITY WAVES OBSERVED ON A TRANSEQUATORIAL RADIO PATH**

J Roettger. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 17 p. refs. (For availability see N73-14131 05-07)

The influence of atmospheric gravity waves on the point-to-point propagation of HF radio waves in the ionosphere is investigated for two cases. The gravity waves are propagating in direction of the great circle between two points, and the gravity waves are propagating transverse to the great circle direction. Measurements on a north-south directed transequatorial HF radio path using fixed frequency CW transmitters show periodical field strength variations during nighttime hours, which are assumed to be caused by focussing due to north-south propagating atmospheric gravity waves. Ray tracing calculations prove that periodical focussing can occur when ionospheric profiles perturbed by atmospheric gravity waves are employed. A power density analysis of the recorded field strength patterns is carried out in order to obtain indications about the main fading periods. Variations in propagation time and azimuth angle indicate traveling ionospheric disturbances moving from west to east in the equatorial zone. Author

**N73-14166** National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab  
**PROPAGATION OF SUBMICROSECOND HF PULSES**

**THROUGH TRAVELLING IONOSPHERIC DISTURBANCES**

G M Larfeld, R B Jurgens, and J A Joselyn. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 21 p. refs. (For availability see N73-14131 05-07)  
(ARPA Order 1361)

HF pulses of submicrosecond duration, received at a range of 1500 km after a single ionospheric reflection from the F region, have been analyzed to study the effects imposed on the pulses by the propagation process. The recorded pulses display a wide variation in form. One pulse characteristic is the pulse stretching attributable to ionospheric dispersion. Typically, for a 1 MHz receiver, the recorded pulse has a duration of about 15 msec. Frequently the recorded pulses also display structure due to polarization splitting and to the reception of time-shifted wavetrains from multiple reflection points (multipath). Some results from the statistical analysis of a large number of pulses include: (1) Occurrence distributions of pulse lengths yield effective ionospheric dispersion rates; (2) time series plots of pulse delay give the amplitude and period of changes in group path; (3) pulse characteristics typically do not change much on a time scale of a few seconds but often change markedly in a few minutes; and (4) detailed analysis of selected pulses shows that the time shifts of multipath components could be derived for the simpler cases. Author

**N73-14166** Uppsala Ionospheric Observatory (Sweden)

**TRAVELLING IONOSPHERIC DISTURBANCES INITIATED BY LOW ALTITUDE NUCLEAR EXPLOSIONS**

W Stoffregen. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 9 p. refs. (For availability see N73-14131 05-07)

Ionospheric disturbances travelling with a maximum velocity of approximately 630 m/s were recorded over the Scandinavian area after two large nuclear explosions. The disturbances in the ionosphere were most pronounced in the F region, as is evident from the ionograms and real height profiles. When the first wave arrived, a spontaneous increase of the height of the F2 layer was observed, followed by splitting of the F layer and a slower phase of recovery. At the E level, a sporadic E layer occurred with some delay and the D region ionization increased during two short periods with a delay of about one hour with respect to the disturbance in the F layer. The time delay of the disturbances at different levels of the ionosphere can be explained by the results of ray tracing studies of the propagation of acoustic gravity waves. Author

**N73-14167** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

**IONOSPHERIC DISTURBANCES GENERATED BY ACUSTIC GRAVITY WAVES RESULTING FROM A 100 kt (20 000 kt) NUCLEAR EXPLOSION ON THE GROUND, OBSERVED AT POINTS LOCATED BETWEEN 160 AND 1000 km FROM THE FIRING SITE**

P M Halley. In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 2 p. (For availability see N73-14131 05-07)

During French nuclear experiments in Polynesia, travelling ionospheric disturbances were observed and their impact on high frequency band propagation was investigated. Various recordings of Doppler effect, frequency shifts and of vertical or oblique soundings are interpreted as exhibiting mainly two disturbance components: (1) A rapid component which is a thermospheric wave whose instantaneous speed is approximately 720 m/s at a horizontal distance of 290 km and then diminishes as the distance increases. This oscillation wave may appear at a very great distance, where its velocity always exceeds 400 m/s. (2) A slow component which could be a ground wave or a guided wave whose velocity is about constant and of the order of 305 m/s. This wave rises up to ionospheric altitudes where it becomes superimposed on the thermospheric wave. The impact of such a disturbance on oblique propagation and the resulting impairment of telecommunication possibilities are discussed. Author

**N73-14168** Paris Univ. (France) Lab. de Physique de l'Exosphere  
**NONLINEAR PROPAGATION AND IONOSPHERIC COUPLING OF ATMOSPHERIC WAVES GENERATED BY A NUCLEAR EXPLOSION**

P. Broche (Centre Univ. de Toulon) In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 13 p. refs. In FRENCH, ENGLISH summary (For availability see N73-14131 05-07)

The disturbance generated in the ionosphere by a nuclear explosion was observed at several points, using the method which consists in measuring the Doppler effect on a HF radio transmission. Two aspects of the results are stressed: (1) The time delay in the occurrence of the disturbance shows that its propagation between the ground and the ionosphere is nonlinear and makes it possible to define a numerical model to describe it, and (2) the time spectrum confirms the considerable influence of the geomagnetic field on the coupling between the motions of neutral particles and those of ionized particles. Author

**N73-14169** Stanford Research Inst., Menlo Park, Calif.  
**NUCLEAR WEAPON EFFECTS ON THE IONOSPHERE (F-REGION DISTURBANCES)**

J. B. Lomax and D. L. Nielson In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 12 p. ref. (For availability see N73-14131 05-07) (Contract. DA-36-039-SC-87197)

The detonation of a nuclear burst at ionospheric heights causes a multiplicity of effects in the ionosphere and therefore on HF communications. Sequences of contour maps of critical frequency are presented in a 16-mm sound/color movie, showing the variation of the F layer maximum electron density as a function of time and space following high altitude nuclear tests. The maps encompass the region 30 deg north and south from the magnetic equator and 35 deg east and west from Johnston Island. The principal effect illustrated is the propagation of ionospheric waves radially outward from the point of detonation. The theory of hydrodynamical waves is also discussed and illustrated in the film, and the observed characteristics of ionospheric waves are presented. Author

**N73-14170** Stanford Research Inst., Menlo Park, Calif.  
**THE EFFECTS OF NUCLEAR-BURST-PRODUCED ACOUSTIC GRAVITY WAVES ON HF COMMUNICATION SYSTEMS**

D. L. Nielson In AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation. Oct 1972. 11 p. refs. (For availability see N73-14131 05-07)

Acoustic gravity waves generated by high altitude nuclear explosions can momentarily affect the performance of HF communications. Two changes can occur: (1) the available propagation spectrum may at some point decrease such that the circuit is no longer operative at a given frequency, and (2) the time-delay and frequency distortions may increase the likelihood of error in a digital system. All effects are subject to the relative orientation of the path, the source, and the geomagnetic field as well as the state of the ionosphere along the path. Author

**N73-23108#** Advisory Group for Aerospace Research and Development, Paris (France)

**RADOMES, ADVANCED DESIGN**

O. Tornani, ed. Mar 1973. 157 p. refs.  
 (AGARD-AR-53) Avail. NTIS HC \$10.00

The techniques of radome design are summarized and a model for radome specifications is presented. The subjects discussed are: (1) environmental design, (2) electrical design, and (3) materials for radome design. Graphs are developed to show radome characteristics under various conditions. Mathematical models are developed to support the theoretical considerations. Author

**N73-26121#** Advisory Group for Aerospace Research and Development, Paris (France)  
**TELECOMMUNICATIONS ASPECTS ON FREQUENCIES BETWEEN 10 AND 100 GHz**

Albert W. Biggs, ed. (Kansas Univ., Lawrence) Apr 1973. 246 p. refs. Presented at Electromagnetic Wave Propagation Panel Tech. Meeting, Gausdal, Norway, 18-21 Sep 1972. (AGARD-CP-107) Avail. NTIS HC \$14.50

The general loss mechanisms of ultrahigh frequency telecommunication systems are studied. Considered are effects of atmospheric absorption and rainfall on radio transmission. For individual titles, see N73-26122 through N73-26143.

**N73-26122** Washington Univ., Seattle. Dept. of Electrical Engineering

**MULTIPLE SCATTERING EFFECTS ON WAVE PROPAGATION THROUGH RAIN**

Akira Ishamaru and James C. Lin In AGARD Telecommunication Aspects on Freq. Between 10 and 100 GHz. Apr 1973. 13 p. refs. (For availability see N73-26121 17-07)

The multiple scattering effects of a wave propagating through rain are studied. In particular, the variances of the in-phase and quadrature components of the wave fluctuation are presented taking into account the beam width of the transmitter and receiver and the scattering and absorption characteristics of a single particle. Expressions for the temporal frequency spectra of the in-phase and quadrature components are formulated taking into account the terminal velocities of the rain drops. Author

**N73-26123** Politecnico di Milano (Italy). Inst. di Elettrotecnica ed Elettronica

**DEPOLARIZATION OF AN ELECTROMAGNETIC WAVE TRAVELING THROUGH A STRATIFIED AEROSOL ON NONSPHERICAL SCATTERING**

C. Capsoni and A. Paraboni In AGARD Telecommunication Aspects on Freq. Between 10 and 100 GHz. Apr 1973. 16 p. refs. (For availability see N73-26121 17-07)

Propagation through an aerosol of non-spherical scatterers having transverse stationary statistical distribution is studied by making use of the equivalence to a stratified homogeneous medium with suitable electric characteristics. Relationships between the degree of depolarization for linearly and circularly polarized waves, the differential propagation and the physical parameters of the medium are determined. Author

**N73-26124** Fengler (C.), Hamburg (West Germany)

**THE PHASE OF A PLANE ELECTROMAGNETIC WAVE TRANSMITTING WIDE SPREAD ATMOSPHERIC DISCONTINUITY**

C. Fengler In AGARD Telecommunication Aspects on Freq. Between 10 and 100 GHz. Apr 1973. 8 p. refs. (For availability see N73-26121 17-07)

For the estimation of multipath propagation and phase delay effects the fundamental processes of refraction and reflection at wide-spread atmospheric discontinuities are treated with the aid of an asymmetrical and a symmetrical Epstein profile. The reflection against an asymmetrical profile as well as the transition through a non-ionized and an ionized layer of symmetrical profile are considered. In particular the phase of the corresponding index of reflection and transmission is evaluated in point of view of frequencies from 10 to 100 GHz and the dimensions of atmospheric inhomogeneities. The treatment shows that at the mentioned propagation processes the phase of the incident wave can vary remarkably, it shows herewith a sensitive dependence on the fluctuating parameters of the atmospheric structure. Author

**N73-26125** Hamburg Univ. (West Germany)

**PHASE MEASUREMENTS WITH MICROWAVES NEAR THE SEA SURFACE**

H. W. Fruchtenicht In AGARD Telecommunication Aspects on Freq. Between 10 and 100 GHz. Apr 1973. 9 p. refs. (For availability see N73-26121 17-07)

Microwave propagation over sea within the E layer may be treated by ray tracing. The resultant phase of the interference field, which is set up in front of the transmitter, depends on the refractivity  $N_{sub} 1$  on a fixed but arbitrary reference level and on the thickness of the maritime evaporation duct. Between the phase and  $N_{sub} 1$  there exists a linear relationship. As a function

of duct thickness, however, the phase reveals a discontinuity amounting to integer multiples of  $2\pi$  but at least  $2\pi$ . Therefore, phase measurements near the sea surface may be many valued.  
Author

**N73-26126\*** Institute for Telecommunication Sciences, Boulder, Colo. Office of Telecommunications  
**ATTENUATION AND PHASE DISPERSION IN THE ATMOSPHERE DUE TO THE MICROWAVE SPECTRUM OF OXYGEN**

H J Liebe and W M Welch /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 18 p refs  
Sponsored in part by NASA and NOAA (For availability see N73-26121 17-07)

Radio wave propagation in the 40- to 140-GHz band through the earth's atmosphere is strongly influenced by the behavior of the O<sub>2</sub> microwave spectrum. This behavior causes the transfer function to depend critically upon altitude. The spectroscopic properties of O<sub>2</sub> are discussed and reduced to engineering formulas expressing attenuation and phase dispersion rates in terms of frequency and meteorological parameters. The theory is supported on several accounts by reliable spectroscopic measurements. Pressure scanning spectroscopy is used to investigate the O<sub>2</sub> microwave spectrum under simulated atmospheric conditions. The application of spectroscopic information to analytical treatments of transfer properties for inhomogeneous slant paths is demonstrated. Attenuation and phase dispersion between 49 and 72 GHz are evaluated for zenith and tangential paths.  
Author

**N73-26127** Bell Telephone Labs, Inc., Holmdel, NJ  
**DEPOLARIZATION OF MICROWAVES IN TRANSMISSION THROUGH RAIN**

D C Hogg /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 5 p refs (For availability see N73-26121 17-07)

Relationships are given for depolarization of linearly and circularly polarized microwaves propagating through rain. Computations using a simple model for the rain medium show that depolarization is more significant for circular than for linear polarization.  
Author

**N73-26128** Bell Telephone Labs, Inc., Holmdel, NJ  
**INTRODUCTION TO SESSION 2**

D C Hogg /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 2 p refs (For availability see N73-26121 17-07)

The following measurements are required in engineering radio communication systems: (1) Attenuation as a function of path length and time, precipitation, atmospheric gases, spatial variations in refractivity, environment; (2) Bandwidth capability, delays within a band caused by the environment, scattering by precipitation, spatial variation in refractivity; (3) Depolarization by the environment, precipitation, antennas; (4) Interference caused by refractivity variations, scattering by precipitation, poor antenna quality, environment; and (5) Phase variations, refractivity changes, precipitation.  
Author

**N73-26129** Fondazione Ugo Bordoni, Roma (Italy)  
**CRITERIA AND EXPECTED ACCURACY OF THE MEASUREMENTS ENVISAGED IN THE RESEARCH PROGRAMME UNDER WAY IN ITALY**

G Fedi /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 23 p refs (For availability see N73-26121 17-07)

The research program on the free propagation of electromagnetic waves at frequencies higher than 10 GHz is outlined. The aims and criteria governing the approach to the program are discussed and an account is given of the radioelectrical and meteorological measurements to be made and the accuracy which may be expected, on the basis of the foreseeable causes of error and the results of preliminary tests already performed.  
Author

**N73-26130** Louvain Univ (Belgium) Microwave Lab  
**EFFECTS DUE TO PRECIPITATION ON HORIZONTAL LINKS AT 12 AND 35 GHz**

A VanderVorst and E Gaudissart /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 6 p refs (For availability see N73-26121 17-07)

Two horizontal line-of-sight links have been installed at 11.7 and 35 GHz in cooperation with meteorological station. A balloon allows measurements to be made in the low atmosphere. The signals are emitted at the top of a tower, reflected back at the top of another building, and received at the location of the emitter. To avoid a coupling between the emitting and receiving antennas, the frequency of the emitted waves is modulated by an amount equal to the intermediate frequency, at a frequency determined by the length of the microwave path. An analog-to-digital conversion allows the data to be computerized; the results at 12 and 35 GHz are autocorrelated, cross-correlated with each other, and cross-correlated with the meteorological parameters. The correlation matrix is used to compute the mean-square regression of the propagation measurements on the meteorological measurements.  
Author

**N73-26131** Mitre Corp., Bedford, Mass.  
**PROPAGATION OF 15.6 - 31.2 GHz AND 45 - 90 GHz COHERENT SIGNAL PAIRS**

John F Sullivan and Harold M Richardson /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 11 p refs (For availability see N73-26121 17-07)

Two pairs of coherent signals have been transmitted through the atmosphere over a 23.1 km path well clear of terrain features. The lower pair of signals spanned 15.6 GHz and the upper pair spanned 45 GHz of the millimeter spectrum. There is no reason to believe that the entire band from 15 to 90 GHz could not be spanned coherently with appropriate apparatus. However, the entire band is not completely useful because of strong absorption near the oxygen absorption lines in the region of 60 GHz and strong temporal and spatially dependent attenuation in the presence of precipitation along the path. It is shown that atmospheric structure imposes commonly minor modulation on mm wave propagation over a limited bandwidth from near zero to a few Hz; this modulation increases with carrier frequency, path length, and intensity of turbulence which in turn varies widely from time to time. Within the limits of the available data, it is concluded that the theory of wave propagation perturbation by turbulent media is valid.  
Author

**N73-26132** Technical Univ of Denmark, Lyngby Lab of Electromagnetic Theory

**IMPROVED DATA FOR PROPAGATION ANALYSIS**

Gregers Mogensen /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 4 p refs (For availability see N73-26121 17-07)

In the planning for a new terrestrial propagation experiment it is found that the complex transfer function vs frequency should be measured in a 1.5 GHz wide frequency range. This transfer function would give the most accurate and usable results since it is not directed towards any particular modulation scheme. Since it is not possible to construct a system for measuring the transfer function, a differential gain-differential phase measurement system is used. The necessary set of formulas to calculate from the measurement data the RF phase curve deviations from a straight line is established. The formulas are tested by numerical simulations and it is found possible to determine the RF phase curve with an accuracy of 1% relative to the peak peak deviations of the phase curve.  
Author

**N73-26133** Federal German Post Office, Darmstadt (West Germany) Research Inst. of the Telecommunication Engineering Center

**SOME OBSERVATIONS OF SCATTERING FROM RAIN ON A 12 GHz TRANS-HORIZON LINK**

N Abel /In AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 13 p refs (For availability see N73-26121 17-07)

A 12 GHz experimental transhorizon link of 210 km length was operated with an elevated receiving antenna beam which



intersected the transmitting antenna beam over approximately the last quarter of the path. The possible scattering angles ranged around 4 degrees, the half power beam width of both antennas was 1.8 degrees. Rain scatter signals were observed via the main lobe of the receiving antenna without any significant restraint, whereas the permanent, but narrow angle turbulence scatter signals were received via side lobes and therefore, reduced to values most barely above threshold. With the aid of fading character and of weather observations, a statistical distribution of rain scatter transmission loss was isolated from the data. During the strongest rain scatter events, the transmission loss was up to 20 db lower than the average loss for turbulence scatter in this particular configuration. Transmission loss values estimated on the basis of rain gauge data seem to be consistent with the measured ones. Author

**N73-26134** Norwegian Defence Research Establishment, Kjeller

**THE INFLUENCE OF PRECIPITATION AND MULTIPATH FADING ON FREQUENCIES BETWEEN 10 AND 18 GHz**  
Odd Gutteberg (Norwegian Telecommun. Admin. Res. Estab., Kjeller) and Anton G. Kjellaas. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 7 p. refs. (For availability see N73-26121 17-07)

Taken the very short measuring time into consideration, the measured attenuation due to rain fits very well the values obtained from rainfall rate in one point applying the reduction coefficient given by Battisti et al. Multipath fading due to atmospheric stratification (duct) has been observed usually during night with nocturnal radiation. The fading depths observed due to multipath are about 1/3 in db of those caused by rain. Author

**N73-26135** McGill Univ., Montreal (Quebec) Dept. of Meteorology

**RAIN ATTENUATION STATISTICS FOR FREQUENCIES ABOVE 10 GHz FROM RAINGAUGE RECORDS**  
G. Drulica. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 15 p. refs. (For availability see N73-26121 17-07)

Tipping bucket raingauge records have been used to generate statistics of rain attenuation at 11.2 GHz for a 5-mile microwave link. The knowledge of storm velocity measured by weather radar is used to transform records into profiles of rainfall rate versus distance. These profiles are then properly integrated over a 5-mile length obtaining simulated attenuation values. These are then compiled as probability curves. A comparison between the actual statistics of the link and the simulated statistics shows good agreement. Author

**N73-26136** Radio and Space Research Station, Slough (England)

**THE INFLUENCE OF RAINFALL ON LINE-OF-SIGHT PROPAGATION AT 110 GHz IN SE ENGLAND**  
D. T. Ulewellyn-Jones and A. M. Zavody. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 6 p. refs. (For availability see N73-26121 17-07)

In the case of millimeter wave propagation through the atmosphere the problem exists of predicting link reliability on the basis of known rainfall data. This requires knowledge of the relationships between rainfall rate at one point and attenuation observed over a given path length. Various methods have been devised to provide more information on these problems at a frequency of 110 GHz. This work involves the use of rain-gauges and spatially separated propagation links. Some results are described, and it is seen that frequencies as high as 110 GHz have potential practical applications over line-of-sight paths of the order of 3 km length. Predicted reliabilities for some applications can be comparable to those obtained at frequencies near 30 GHz. Author

**N73-26137** Technical Univ. of Denmark, Lyngby Lab. of Electromagnetic Theory

**EXTRAPOLATION OF PROPAGATION DATA**  
P. Gudmandsen. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 2 p. refs. (For availability see N73-26121 17-07)

A short description is given of a plan to use field strength recordings on one path for prediction of the performance of another path with somewhat different weather conditions based on weather data recorded simultaneously. The influence of rain on the performance of communication links at frequencies in the range 10 - 18 GHz is considered. Author

**N73-26138** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

**EXPERIMENTAL METHOD OF MEASURING PROPAGATION ATTENUATION OF RAIN [METHODE EXPERIMENTALE DE MESURE DE L'AFFAIBLISSEMENT DE PROPAGATION DU A LA PLUIE]**

P. Misme, L. Boithias, and J. Battisti. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 6 p. ref. In FRENCH. (For availability see N73-26121 17-07)

After having given a theoretical definition of equivalent precipitation intensity, it is pointed out how this quantity may be calculated experimentally with the help of propagation results. The value of a reduction coefficient, function of the length of a connection and percentage of time are described. Consequently, with the help of experimental results, a method is developed that permits calculation of absorption as a product of rain for a percentage of any time and for all frequencies less than frequencies in the vicinity of 30 GHz and distances less than about 20 kilometers. Author

**N73-26139** Communications Research Centre, Ottawa (Ontario)

**AMPLITUDE FADING OF SATELLITE COMMUNICATIONS SIGNALS AT SHF**

K. S. McCormick, R. L. Olsen, and L. A. Maynard. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 8 p. refs. (For availability see N73-26121 17-07)

For SHF satellite communications systems designed to operate at elevation angles less than several degrees, allowance must be made for fluctuations in the signal level caused by variations in the refractive structure of the troposphere. As part of a program to investigate these effects, the signals from satellite beacons at 7.3 GHz have been monitored during several periods over the last five years. The results show that in the summer months, the fading is greater than 10 db for 0.1% of the time at elevation angles below three degrees, while, for the winter months, fades greater than 6 db occur under the same conditions. A limited series of observations at resolute (latitude 75 N) show that in the Arctic, the fading in the summer is similar to that which occurs in Ottawa in the winter. Author

**N73-26140** Radio and Space Research Station, Slough (England)

**SLANT PATH ATTENUATION AT FREQUENCIES ABOVE 10 GHz**

P. G. Davies. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 11 p. refs. (For availability see N73-26121 17-07)

Results obtained from solar tracking radiometer measurements made at 19 GHz and at 37 GHz have been studied to give data on attenuation (primarily caused by rain) on paths through the troposphere. Such information is required in the planning and operation of microwave links to and from satellites. The results are presented in statistical form as cumulative distributions of the percentage of the observation time for which the attenuation exceeds various values. Analysis of individual fades exceeding 5 and 10 db at both 19 and 37 GHz has also been carried out and the results are presented as histograms showing the number of fades as a function of fade duration. Author

**N73-26141** Texas Univ., Austin Electrical Engineering Research Lab

**STATISTICS ON EARTH SATELLITE ATTENUATION AT TWO TEXAS LOCATIONS**

A. W. Straiton, David N. Pate, and Bob M. Fannin. In AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz. Apr. 1973. 9 p. refs. (For availability see N73-26121 17-07)

Propagation experiments using the 15.3 GHz transmitter on the ATS-5 satellite as a signal source are reported. Signal strength

data were recorded at two locations at Austin in central Texas for twenty months and at Mount Locke in far west Texas for five weeks. The elevation angle in each case was near 54 deg. It is concluded that for high elevation angles severe attenuation is almost always associated with thunderstorms. Curves of percentage of time versus path attenuation for an average year are given for both sites. The height of the top of the thunderstorm cloud was found to be a fairly good single indicator of the intensity and duration of fades. Author

**N73-26142** Communications Research Centre, Ottawa (Ontario). Dept. of Communications

**COMPARISON OF DIRECT AND INDIRECT MEASUREMENTS OF PRECIPITATION ATTENUATION AT 15.3 GHz**  
J. I. Strickland. In AGARD Telecommun Aspects on Freq Between 10 and 100 GHz. Apr 1973. 8 p. refs. (For availability see N73-26121 17-07)

The signal strength received at 15.3 GHz from the ATS-5 satellite was measured using a 9 metre antenna. The receiving antenna is also connected as a total-power radiometer, providing simultaneous measurements of the sky noise temperature at 15.3 GHz with an antenna beamwidth of 0.15 degrees. Attenuations, calculated from the measured sky temperatures, show very good agreement with the directly measured attenuations. Author

**N73-26143** Aerospace Corp., El Segundo, Calif. Electronics Research Lab

**SPACE COMMUNICATIONS SYSTEMS CONSIDERATIONS AT 24 GHz**

H. J. Wintroub and L. A. Hoffman. In AGARD Telecommun Aspects on Freq Between 10 and 100 GHz. Apr 1973. 17 p. refs. (For availability see N73-26121 17-07)

The effects of atmospheric physical phenomena in determining satellite-ground radio link performance are considered. Experimental data are presented as a basis for the determination of link margins and tradeoffs between communication capacity and outage because of rain-induced attenuation or high atmospheric turbulence. State-of-the-art and predicted performance of future millimeter wave components are considered in formulating the spacecraft and ground terminal systems. Included are a beam swinging experiment using a precision controlled 4.57-m antenna to obtain data on wavefront tilt fluctuations, time histories of amplitude scintillation for 0.15-, 0.61-, and 4.57-m apertures, and statistical data on water vapor attenuation. Author

**N73-32053#** Advisory Group for Aerospace Research and Development, Paris (France)

**SPREAD SPECTRUM COMMUNICATIONS**

Jul 1973. 198 p. refs.  
(AGARD-LS-58) Avail NTIS HC \$12.00

The theory, implementation, and application of state-of-the-art spread spectrum techniques to advanced communication systems are discussed. The fundamental and theoretical aspects of communication theory, digital communications theory, and spread spectrum communications are reported. The practical aspects of spread spectrum techniques, particularly the performance and synchronization considerations, and several state-of-the-art applications are described. Predictions of future communication systems with spread spectrum methodology are included. For individual titles, see N73-32054 through N73-32058.

**N73-32054** Rensselaer Polytechnic Inst., Troy, N.Y. Systems Engineering Div

**SOME FUNDAMENTAL NOTIONS OF COMMUNICATION THEORY**

Lester A. Geihardt. In AGARD Spread Spectrum Commun. Jul 1973. 24 p. refs. (For availability see N73-32053 23-07)

The basic concepts of communications theory to include the transmission of continuous signals and the use of discrete time signals are presented. A numerical analysis of communication signals, the spectral characteristics of the signals, and a probabilistic description of the signals are developed. The basic types of modulation, to include amplitude, pulse, and angle

modulation and related forms are examined. The characteristics of the signal receiver with emphasis on signal detection and filtering are described. The effect of the sampling theorem on the spectral characteristics of signals is analyzed. The problems of quantization are outlined for discrete time and discrete amplitude signals. Author

**N73-32055** Manchester Univ. (England). Dept. of Electrical Engineering and Electronics

**DIGITAL COMMUNICATIONS THEORY**

Geoffrey F. Gott. In AGARD Spread Spectrum Commun. Jul 1973. 16 p. refs. (For availability see N73-32053 23-07)

The characteristics of digital communication systems and the processing of bandpass digital signals are discussed. The modulation and detection of frequency shift keyed and phase shift keyed signals are considered in binary and multilevel form. Emphasis is placed on radio frequency data transmission where spread spectrum techniques have application. Methods of providing protection against the effects of signal fading due to multipath propagation are analyzed. Elementary forward error correcting codes of the type used in radio frequency channels are examined. Author

**N73-32056** Signals Research and Development Establishment, Christchurch (England)

**INTRODUCTION TO SPREAD SPECTRUM TECHNIQUES**

R. L. Harris. In AGARD Spread Spectrum Commun. Jul 1973. 21 p. (For availability see N73-32053 23-07)

The basic principles and operation of a spread spectrum communication system are discussed. Spectrum spreading by means of direct modulation is considered in detail and compared with an alternative method using frequency hopping. A key feature of any spread spectrum system is the pseudo random sequence and the basic properties and generation of such sequences are discussed. Finally the performance of a typical satellite communication system using spread spectrum as a multiple access method is calculated. Author

**N73-32057** Communications Research Centre, Ottawa (Ontario)

**PERFORMANCE AND SYNCHRONIZATION CONSIDERATIONS**

N. G. Davies. In AGARD Spread Spectrum Commun. Jul 1973. 24 p. refs. (For availability see N73-32053 23-07)

The performance of spread spectrum systems in the presence of various forms of channel noise is analyzed. The synchronization aspects of spread spectrum systems are examined. The subjects discussed are (1) acquisition by search in the time and frequency domains, (2) the use of preambles and special sequences for synchronization, and (3) the establishment of synchronization detection and tracking criteria. Author

**N73-32058** Magnavox Research Labs, Torrance, Calif.

**SPREAD SPECTRUM APPLICATIONS AND STATE OF THE ART EQUIPMENTS**

Charles R. Cahn. In AGARD Spread Spectrum Commun. Jul 1973. 111 p. refs. (For availability see N73-32053 23-07)

The applications of spread spectrum communications to avionics systems are described. The following topics are discussed: (1) multiple access capabilities, (2) interference rejection, (3) identification characteristics, and (4) distance measuring and position location capabilities. The characteristics and uses of current spread spectrum equipment are reported. Recent technology discoveries, such as acoustic surface wave and charge coupled devices are explained. Author

**N74-11954#** Advisory Group for Aerospace Research and Development, Paris (France)

**DETERMINATION AND USE OF RADAR SCATTERING CHARACTERISTICS**

Sep 1973. 171 p. refs. Conf. held at Bolkesjoe, Norway, 11-12 Oct 1973. London, 15-16 Oct 1973. The Hague, 18-19 Oct 1973.

(AGARD-LS-59) Avail NTIS HC \$10.75

Radar echoes and radar cross sections are reviewed for different classes of targets, main parameters affecting backscatter signal are analyzed. For individual titles, see N74-11955 through N74-11967.

**N74-11955** EMI Electronics Ltd., Wells (England)  
**INTRODUCTORY LECTURE: TARGET SCATTERING CHARACTERISTICS OF IMPORTANCE TO RADARS**  
L R Cram *In AGARD Determination and Use of Radar Scattering Characteristics* Sep 1973 4 p (For availability see N74-11954 03-07)

Scattering characteristics of interest include the Doppler content, the range noise and the angular glint as well as the radar cross section (RCS), or radar echoing area (REA). A definition is given of these parameters (RCS or REA) and the physical reasons for variations around a target are discussed. Both amplitude and rate of change significantly affect radar performance. Reciprocally, the value of the radar echoing area can itself be affected by the radar parameters such as modulation type, frequency and polarization. Target glint will affect the accuracy of directional information provided by the radar. The rates of change and frequencies of change of glint are also important. Radar parameters and the glint data interact with each other in that polarization characteristics of the radar affect the glint and its frequencies while the significance of glint frequencies depends on radar servo rates, etc. Targets which are of interest include land, sea and airborne vehicles. Sea and land reflections represent either clutter or targets in their own right. Birds represent hazards to aircraft so their radar scattering is also of interest. Author

**N74-11956** Ohio State Univ., Columbus. ElectroScience Lab  
**COMPUTATIONAL AND ANALYTICAL DETERMINATION OF RCS**

Edward M Kennaugh *In AGARD Determination and Use of Radar Scattering Characteristics* Sep 1973 9 p refs (For availability see N74-11954 03-07)

Improvements in computational techniques for calculation of RCS now permit wider ranges of objects to be analyzed. The lecture reviews the state of the art at present, with a description of two basic approaches. The point matching or wire grid model utilizes a matrix description of a three dimensional shape and proceeds to calculate RCS through solution of a large order system of linear equations. The asymptotic or quasi-optical solution identifies key contributions to RCS which may be given simple mathematical description and summed automatically, with proper account of phasing, as a function of attitude. The limitations and virtues of each method are described, and the possibility of combining both computational methods is explored. Illustrative examples are presented, and the importance of this tool as an adjunct to experimental RCS studies is discussed. Author

**N74-11957** Test Group (6585th), Holloman AFB, N Mex. Radar Target Scatter Facility

**STATIC FULL SCALE MEASUREMENTS OF RCS**

Carroll R Griffin, Jr. *In AGARD Determination and Use of Radar Scattering Characteristics* Sep 1973 11 p (For availability see N74-11954 03-07)

A number of techniques for the measurement of radar cross section are discussed and compared. A description of the theory of operations of a ground plane range is provided. Some considerations for use and some of the advantages of the ground plane method result from the theory. A description of the equipment and methods for obtaining RCS data is followed by a description of special measurement systems available. Finally, a brief description of the functional organization required in the operation of an RCS measurement site is provided. Author

**N74-11958** Air Force Avionics Lab., Wright-Patterson AFB, Ohio. Observables Group

**DYNAMIC FULL SCALE MEASUREMENT OF RCS**

William F Bahret *In AGARD Determination and Use of Radar Scattering Characteristics* Sep 1973 16 p refs (For availability see N74-11954 03-07)

Trade offs and technical considerations in dynamic measurements of radar cross section are discussed to establish require-

ments for instrumentation and techniques used for such measurements. Primary emphasis is given to aircraft targets although most of the discussion applies to sea or land based targets as well. Block diagrams of practical systems for measuring amplitude and angular scintillation are presented and discussed. Typical output data are related to the primary user requirements. Author

**N74-11959** EMI Electronics Ltd., Wells (England)  
**MODELLING METHODS OF DETERMINING RADAR ECHO CHARACTERISTICS**

L A Cram *In AGARD Determination and Use of Radar Scattering Characteristics* Sep 1973 7 p (For availability see N74-11954 03-07)

Optical modelling is now rarely used but ultrasonic modelling is far more effective. A well instrumented facility for ultrasonic modelling is described which operates in water with wavelength scaling from 1/10 to 1/40. Speedy operation and good range discrimination are particularly advantageous. Radio scale modelling has additional advantages and a radio scale modelling facility incorporating five different measuring equipments is described. Mutual interference is avoided by range gating the radars. Scaling is from 1/1 to 1/100 and many different radars operate from 1 GHz to 100 GHz. Targets of metal coated wood are suspended by nylon strings. Two general purpose equipments permit flexible choice of radar system, aerial type, wavelength and polarization. Other systems are specialized for investigating the end course of a missile radar, the reflections from sea waves and the effects of target glint on radar aiming errors. A radar system assessment team with computers completes the radio modelling facility. Author

**N74-11960** EMI Electronics Ltd., Wells (England)

**TARGET CHARACTERISTICS**

S C Woolcock *In AGARD Determination and Use of Radar Scattering Characteristics* Sep 1973 28 p refs (For availability see N74-11954 03-07)

A knowledge of the radar scattering properties of complex targets is a necessary requirement for the detailed study of modern radar systems. The use of computers for such studies requires that these properties shall be described in compact form. By making radar measurements of high quality scaled models a better understanding of target reflectivity is being achieved. The dependence of the received signal on the frequency and polarization of the incident field as well as on the characteristics of the radar system is described. Reflections from simple shapes are discussed to show how the radar cross section can be computed by geometric optics, physical optics and by consideration of travelling wave echoes. The sources of radar reflection for an aircraft and for a missile shape are next discussed. These were determined by measurement. There follows an introduction to the concept of angular glint. Glint properties of a complex target are described and associated with the perturbations on phase fronts. Features of glint are highlighted, in particular the wander of the mean glint centre with the target outline. Finally an example is shown of Doppler spectra obtained from an aircraft. Spectral lines associated with moving parts are usually present. In this instance several frequency components have arisen which can be associated with the rotating turbines of engines. Author

**N74-11961** Royal Radar Establishment, Malvern (England)

**RADAR ECHOING AREAS OF FLYING ANIMALS**

E W Houston *In AGARD Determination and Use of Radar Scattering Characteristics* Sep 1973 11 p refs (For availability see N74-11954 03-07)

The echo signal from a flying animal consists of at least two components: an average or mean component and an amplitude modulated component. The mean component is proportional to the slow variations in echoing area, resulting from long term variations of the animal's aspect as it flies past the radar. The modulation component follows the rapid variations generated by wing flapping or by transient fluctuations in echoing area produced, for example, by head movements. The periodic wingbeat modulation of the echo signal from even a small bird is distinctive and makes it easy to separate this form of target out from echoes. By selective measurements on flying animals

under laboratory conditions the task of specifying radar echoing areas can be reduced when these static cross sections are compared with dynamic echoing areas measured on animals in flight. Author

**N74-11962** Royal Radar Establishment, Malvern (England)  
**RADAR SEA CLUTTER**

Geoffrey Bishop. In AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 21 p (For availability see N74-11954 03-07)

Radar sea clutter studies have been made based on a series of trials, in which X-band non-coherent radar measurements have been taken from a cliff top site in Cornwall, England. Horizontal, vertical and circular polarizations were transmitted using pulse lengths of 70 nanosec and 270 nanosec with an antenna beamwidth of 0.6. Horizontal, vertical or both hands of circular polarization were received. Amplitude distribution curves show the effects of change in sea state, polarization and pulse length on the cross sectional echoing area characteristics of sea clutter and moored buoy targets. Cross polarization effects have been studied. Autocorrelation analyses of the recorded radar returns show clutter decorrelation times varying from 5 milliseconds to several seconds. Author

**N74-11963** Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany)

**THE USE OF TARGET AND CLUTTER DATA FOR DIFFERENT METHODS OF DISCRIMINATION BETWEEN TARGETS AND UNWANTED CLUTTER**

Karl VonSchlachte. In AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 21 p refs (For availability see N74-11954 03-07)

The signal processing procedures adopted in surveillance radars for discriminating target and clutter are based on results of statistical decision theory. The practical implementation is discussed with reference to two groups of radar and the influence of target and clutter characteristics are pointed out. A first group comprises the processing of incoherent video signals. The examples are the sequential detection device, the Scan to Scan MTI and procedures for fast switching between normal and MTI video signal. A second group deals with the processing of coherent radar signals. The Doppler information of moving targets is used for the discrimination between targets and unwanted clutter. A modern device applying the likelihood ratio test and using Doppler filters in the time domain is described. Further investigations are made for suppression of moving clutter by adaptive filtering. Author

**N74-11964** Test Group (6585th), Holloman AFB, N Mex. Radar Target Scatter Facility

**PRESENTATION AND STORAGE OF RADAR CROSS-SECTION DATA**

Carroll R. Griffin, Jr. In AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 24 p (For availability see N74-11954 03-07)

The data required to be taken in conjunction with the measurement of radar cross sections are divided into two categories: that associated with the target orientation or aspect and that associated with the radar measurement parameters. Several types of presentation are used, and various types of records of the data are available, both analog and digital. The standardization of data formats and conventions for target orientations are important objectives which should be established for the benefit of users of RCS data. Author

**N74-11965** EMI Electronics Ltd., Wells (England)

**USE OF RADIO MODELLING DATA**

S. C. Woolcock. In AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 13 p refs (For availability see N74-11954 03-07)

The U.K. radio modelling facility has permitted the amassing of much data concerning reflections from a wide variety of radar reflecting objects at many different frequencies and at all possible polarization configurations. The data must be reduced by a method which does not remove details of the scattering signal to which the radar system is sensitive. Three methods are in

use: (1) Statistical summaries such as cumulative probability, spectral distribution, autocorrelation function or mean value and standard deviation; (2) look-up table (no data reduction) using computer storage data on echo characteristics of targets; and (3) multiple source mathematical models that represent a target by a number of elementary sources, each of defined strength, polar diagram and position. A radar analysis example is given where a simple computer program determines the performance of a sequential lobing radar in locating a shell whose polar echo characteristics are fed directly from a recording of the radio range data. Author

**N74-11966** Air Force Avionics Lab., Wright-Patterson AFB, Ohio. Observables Group

**THE USE OF RCS DATA**

William F. Bahret. In AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 10 p refs (For availability see N74-11954 03-07)

Data requirements and limitations are emphasized that are associated with systems analysis involving radar cross section, rather than the mechanics of any actual analysis. Treated separately as increasingly sophisticated levels of target characterization are far zone, near zone, and glint data. Typical applications and practical requirements for these applications are discussed to define adequate methods for obtaining and presenting RCS data. The general theme is that applying RCS data is rather straightforward provided that truly pertinent and accurate data are available in suitable form. On the other hand, to settle for less in the way of RCS data is to gamble an expensive system design to save the relatively small investment for obtaining proper data. Author

**N74-11967** EMI Electronics Ltd., Wells (England)

**STATE OF THE ART AND FUTURE PROSPECTS**

C. A. Cram. In AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 11 p (For availability see N74-11954 03-07)

The state of the art regarding radar scattering characteristics and their acquisition and use is summarized. It is indicated how a choice may be made among the various methods for finding and for using radar cross section data to assess radar performance. Those are many methods of collecting radar data. Each has its different disadvantages but when the various methods are used with care and within their limitations they give consistent and comparable results with one another. Hence bearing in mind the appreciable costs it is important to choose an optimum use of the various methods. This optimum will often mean some use of all of the techniques. Each radar systems investigation must be examined to determine the particular optimum procedure for finding the echo data needed for that study. Author

**N74-13846** Advisory Group for Aerospace Research and Development, Paris (France)

**PROPAGATION EFFECTS OF FREQUENCY SHARING**

L. Ranzani, ed. (1st Super P.T. Viale Trastevere) Sep. 1973 307 p. In ENGLISH, partly in FRENCH. Presented at the Specialists Meeting of the Electromagnetic Wave Propagation Panel, Rome, 7-11 May 1973.

AGARD-CP-1271. Avail. NTIS HC \$17.50

Problems related to the propagation effects which may influence the feasibility of frequency sharing among various telecommunication services are considered. For individual titles see N74-13847 through N74-13871.

**N74-13847** Radio and Space Research Station, Slough (England)

**INTRODUCTORY SURVEY TO SESSION 1 PROPAGATION OVER IRREGULAR TERRAIN**

R. W. Meadows. In AGARD Propagation Effects of Freq. Sharing Sep. 1973 2 p (For availability see N74-13846 05-07)

A survey is presented on the general problem of predicting wave propagation loss over irregular terrain and the production of unwanted high signal levels at a distance. Mathematical predictions of terrain screening effects and field strength for a ground path of a given profile are considered in suitable siting selections for communication terminals. G. G.

**N74-13848** British Broadcasting Corp. Kingswood (England)  
**THE PROPAGATION OF ELECTROMAGNETIC WAVES OVER IRREGULAR TERRAIN**

R. W. King and H. Page. In AGARD Propagation Effects of Freq. Sharing Sep 1973. 20 p. refs. Prepared in cooperation with Imp. Coll. of Sci. and Technol. (For availability see N74-13846 05-07)

A method is proposed for calculating the field strength of radio frequency signals propagated over irregular terrain; a typical application is to estimate the diffraction loss in the shadow of hills, or similar obstacles, for terrestrial transmitters working on frequencies between 50 and 1000 MHz. Approximations are made in the theoretical treatment in order to make the method sufficiently simple to be used in the planning of practical systems. The ground irregularities are regarded as approximating to one or other of a set of standard obstacles; the extent of the local irregularity which determines the effective obstacle shape is determined, thus enabling irregular ground to be approximated to a series of the standardized obstacles. The diffraction loss is deduced first for single obstacles and then for multiple obstacles; the obstacles are assumed to be smooth, but the effect of roughness is discussed. The theoretical results are compared with measurements using small scale models and also with practical field surveys. Author

**N74-13849** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

**ROLE OF ATMOSPHERIC DUCTS IN THE PHENOMENA OF INTERFERENCE OVER LARGE DISTANCES (ROLE DES CONDUITS ATMOSPHERIQUES DANS LES PHENOMENES DE BROUILLAGE A GRANDE DISTANCE)**

P. Misme. In AGARD Propagation Effects of Freq. Sharing Sep 1973. 12 p. refs. In FRENCH (For availability see N74-13846 05-07)

A theory was developed to serve as a guide to propagation interference caused by atmospheric ducts. Data cover leakage coefficients, propagation curves, and the influence of terrain and water on propagation. Transl. by E. H. W.

**N74-13850** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

**EFFECT OF TERRAIN SCREENING ON THE DIFFERENT MECHANISMS OF PROPAGATION (EFFET D'ECRAN DU TERRAIN POUR LES DIFFERENTS MECANISMES DE PROPAGATION)**

L. Boithias. In AGARD Propagation Effects of Freq. Sharing Sep 1973. 9 p. refs. In FRENCH (For availability see N74-13846 05-07)

The influence of various terrain screening techniques on propagation mechanisms is investigated. Data are included on diffraction by ridges, spherical diffraction, tropospheric diffusion, precipitation diffusion, refraction, and reflection. Particular attention was given to the role played by local relief. Transl. by E. H. W.

**N74-13851** Imperial Coll. of Science and Technology, London (England)

**RADIO WAVE DIFFRACTION DUE TO A MOUNTAIN OF VOLCANIC ORIGIN**

W. G. Burrows and J. D. Ridler. In AGARD Propagation Effects of Freq. Sharing Sep 1973. 26 p. refs. (For availability see N74-13846 05-07)

A simple modelling technique is employed to examine the field distribution in the shadow of a mountain obstacle which is approximately conical in overall shape and typical of one of volcanic origin. The experimental procedure includes measurements of the field distributions in the shadows of a right circular cone representing the ideal mountain shape, and a right circular cone whose surface contours are modified to give an approximate scale model representation of an actual mountain. Distributions are also obtained for the field intensities in the shadow regions of these obstacles when the air over their upper surfaces supports a temperature gradient which is subjected to the additional influence of an air stream. Results are given to indicate, by comparison with those obtained for a simple knife edge representing the mountain, the magnitudes of the errors that

might arise in the calculation of the obstacle loss or gain for a radio path when no account is taken of the obstacle shape and the state of the atmospheric medium above its surface. Author

**N74-13852** Research Inst. of National Defence, Stockholm (Sweden)

**VARIATIONS IN DIFFRACTION LOSS DUE TO TROPOSPHERIC EFFECTS AT FREQUENCIES BETWEEN 180 MHz AND 10 GHz IN HILLY TERRAIN**

Ake Blomquist, Folke Eklund, and Lennart Nilsson. In AGARD Propagation Effects of Freq. Sharing Sep 1973. 13 p. refs. (For availability see N74-13846 05-07)

The variations in time of the diffraction loss at the frequencies 180, 2300 and 9350 MHz have been studied over a 30 km path in irregular terrain typical for central Sweden during a period of about 3 years. In addition to these measurements, short term field strength recordings have been carried out at 44, 66, 88 and 1000 MHz. The angular distance of the path was 0.38 deg. The diffraction loss over the path was normally quite constant at the frequencies studied. The stable signal had, however, a superimposed component of very small amplitude with rapid fading probably due to turbulent scatter. Mainly at night during summer it occurred that the screening effect was considerably reduced due to propagation disturbances caused by layered tropospheric structures. Two different types of signal can then be distinguished: rapid amplitude variations of irregular character with a somewhat higher average level compared to the stable signal mentioned above, and rather slow amplitude variations with deep fading minima of regular character and with a much higher average level than the stable one. Statistics of the variations in diffraction loss are presented and possible propagation mechanisms causing the variations are discussed. Author

**N74-13853** Centro Radioelettrico Sperimentale G. Marconi, Rome (Italy)

**TROPOSPHERIC INFLUENCE ON THE SCREENING EFFECT DUE TO A MOUNTAIN RIDGE, ON 3 GHz**

I. Ranzi and P. Giorgi. In AGARD Propagation Effects of Freq. Sharing Sep 1973. 3 p. (For availability see N74-13846 05-07)

During one year, measurements have been carried out of the basic propagation loss at 3.04 GHz in a 56.2 km path, comprising a mountain flat top of 933 m of height. The annual median value of the basic propagation loss resulted to be 220.7 db; the median loss due to obstacle was 83.7 db; that is more than 45 db higher than the loss due to a knife edge obstacle. The statistical analysis of the received signal showed the presence of a Rayleigh component and of a slow fading component; the monthly median value of the last component was about 10 db lower than the Rayleigh component on January and 3 db lower on June. As the monthly median signal amplitude increased by about 14 db from January to June, it seems that an important contribution derived from partial reflections from relatively stable layers above the mountain top. Author

**N74-13854** Computer Sciences Corp., Falls Church, Va.  
**PRECIPITATION MODELS FROM RADAR AND RAINFALL DATA**

Frederick J. Altman. In AGARD Propagation Effects of Freq. Sharing Sep 1973. 18 p. refs. (For availability see N74-13846 05-07)

To guide estimates of attenuation and scattering of radio waves, a model for spatial distributions of reflectivity in storm cells has been fitted to digitized radar data. The model assumes ellipses for contours of constant reflectivity factor Z, with constant orientation and eccentricity within a horizontal cell cross section at a given time and evaluation. The centers of the ellipses are assumed uniformly spaced on a straight line with areas linearly related to log Z, except for cell tops and bottoms, and for splitting, the cross sections were similar at different heights, especially for the highest reflectivities. In an attempt to relate reflectivity aloft to surface rainfall, similar radar data and hourly rainfall from 30 stations within a circular area about 200 km in radius were used to study precipitation distributions in time and space. Both types of data were found to provide similar distributions, with useful correlations among several parameters. Author

**N74-13855 Deutsche Bundespost, Darmstadt (West Germany)  
MEASUREMENTS OF PRECIPITATION SCATTER AT  
11.6 GHz**

F Dintelmann and F Ruecker. In AGARD Propagation Effects of Freq Sharing Sep 1973 6 p refs (For availability see N74-13846 05-07)

A bistatical experimental study of precipitation scatter at 11.6 GHz is proposed that uses simultaneously steerable transmitting and receiving antennas separated by a large area. This allows for scatter observations on rainshowers crossing the radio link and to determine the structure and dynamics of rain cells. G G

**N74-13856 Office of Telecommunications, Boulder, Colo  
ESTIMATING ATTENUATION, SCINTILLATION, AND  
SCATTERING DUE TO RAINFALL FOR SATELLITE  
GROUND SYSTEMS**

H T Dougherty and E J Dutton. In AGARD Propagation Effects of Freq Sharing Sep 1973 13 p refs (For availability see N74-13846 05-07)

A state-of-the-art engineering model is described for estimating the expected performance degradation of satellite-to-ground microwave systems because of atmospheric gases, clouds, and rain. The model incorporates an allowance for the spatial structure of atmospheric gases, clouds and rain as well as local and regional rainfall statistics. The estimates are in terms of attenuation and scintillation as well as the volume reflectivity which contributes to co-channel interference. Composite predictions are given for 15 GHz as representative of microwave signals for small percentages of an average year. This prediction is a function of location and the angle-of-arrival at ground stations on the central east coast of the U S A. Author

**N74-13857 Technische Hogeschool, Eindhoven (Netherlands)  
INTRODUCTORY SURVEY TO SESSION 3 CONTROL OF  
ANTENNAE SIDE LOBES**

B VanDijl. In AGARD Propagation Effects of Freq Sharing Sep 1973 9 p refs (For availability see N74-13846 05-07)

After a short discussion of the importance of side lobes for communication networks and of their physical background, the emphasis is laid on the development of insight in the possibilities of influencing near angle side lobes. The effect of blocking of the aperture by obstructions is discussed in general terms and an estimate is made of the magnitude of the blocking effect. Author

**N74-13858 Technische Hogeschool, Eindhoven (Netherlands)  
SOME ASPECTS OF NEAR AND FAR ANGLE SIDELOBES  
IN DOUBLE-REFLECTOR ANTENNAS**

J Dijk and E J Maanders. In AGARD Propagation Effects of Freq Sharing Sep 1973 16 p refs (For availability see N74-13846 05-07)

Analysis and synthesis of the directive gain pattern of reflector antennas, especially Cassegrain antennas are considered. After a short introduction into the geometry of classical and shaped Cassegrain antennas, scalar aperture theory is used in a method to calculate the main lobe and near angle sidelobes of a blocked aperture. Scalar aperture theory is also used to calculate the sidelobes of mismatched shaped Cassegrain antennas. The second part of the paper deals with far angle sidelobes. An example of Kirchhoff integration is shown and finally it is demonstrated that by shaping main and subreflector power scattered by subreflector and supports may be transported in the correct phase to the aperture, decreasing far angle scattering. Author

**N74-13859 Societa Italiana per l'Esercizio Telefonico, Rome (Italy)  
THE RADIATION DIAGRAMS OF ANTENNAS USED IN  
TERRESTRIAL MICROWAVE LINE-OF-SIGHT SYSTEMS**

C Colavito and G Masone. In AGARD Propagation Effects of Freq Sharing Sep 1973 8 p refs (For availability see N74-13846 05-07)

Measurements carried out on parabolic disk antennas used in terrestrial microwave line of sight relay systems are reported. These systems are allocated in the 7 GHz frequency band which is shared between terrestrial and satellite fixed services. The

measurements have been performed in a field where the free space propagation conditions were approximated, as well as in the real installation conditions. In the two above mentioned situations, the smoothed envelopes of the radiation diagrams have been obtained for different types of antennas. Some conclusive remarks are made concerning the characteristics of the terrestrial radio relay antennas to be considered in the interference analyses. Author

**N74-13860 Louvain Univ (Belgium)  
SYNTHESIS OF APERTURE DISTRIBUTIONS FOR OP-  
TIMUM GAIN WITH NOISE AND INTERFERENCE REJEC-  
TION**

M Safak and P Delogne. In AGARD Propagation Effects of Freq Sharing Sep 1973 12 p refs (For availability see N74-13846 05-07)

Synthesis of the aperture distributions yielding the best rejection of noise or interfering sources located in a given region of the radiation pattern is examined. Previous methods are reviewed. It is shown that they are not always optimum or require too much computer time, or yield too complicated distributions for practical purposes. The proposed method permits the optimization of the gain-to-temperature ratio for an arbitrary distribution of noise and interfering sources; it avoids superdirectivity and even unnecessary sophistication of the distribution. Results are presented for linear and circular apertures with symmetrical distributions. Author

**N74-13861 Fondazione Ugo Bordoni, Rome (Italy)  
INTRODUCTORY SURVEY TO SESSION 4. PROPAGATION  
DATA FOR INTERFERENCE PROBABILITY DETERMINA-  
TIONS**

F Fedi. In AGARD Propagation Effects of Freq Sharing Sep 1973 5 p refs (For availability see N74-13846 05-07)

Varied aspects of tropospheric propagation and interference probability calculation methods are considered for a wide range of frequencies. Wave scattering, reflecting and ducting phenomena are studied as well as attenuation due to the atmosphere and to precipitations both for terrestrial and satellite radio links. G G

**N74-13862 SIGMA Association, Hamburg (West Germany)  
DUCTING PROPERTIES OF ELEVATED LAYERS**

C Fangler. In AGARD Propagation Effects of Freq Sharing Sep 1963 9 p refs (For availability see N74-13846 05-07)

Field strength observed at VHF and UHF transhorizon paths exceeds considerably the average value in 10% of time. These 10% values are due to the influence of elevated layers if ground based layers are absent. In the referred observations at individual paths the obvious explanation by reflection processes fails because of ray geometry. Ducting mechanisms have to be assumed. The possibilities of ducting are generally considered in point of view of ray theory, wave optics, and path geometry for various tropospheric profiles. Author

**N74-13863 Research Inst of National Defence, Stockholm (Sweden)  
THE OCCURRENCE OF VERY HIGH FIELD STRENGTHS  
AT BEYOND THE HORIZON PROPAGATION OVER SEA  
IN THE FREQUENCY RANGE 60 - 5000 MHz**

Sture Wickerts and Lennart Nilsson. In AGARD Propagation Effects of Freq Sharing Sep 1973 15 p refs (For availability see N74-13846 05-07)

The occurrence of enhanced fields has been studied over a sea path of 160 km at the frequencies 170 MHz, 460 MHz and 5000 MHz. For short periods also 60 MHz was used. Long term measurements of field strength have been performed since 1968, which includes some period of meteorological measurement. For these measurements an airborne refractometer, captive balloon sondes and an acoustic sounder were used. The received signals can be classified by the following three types: Standard atmosphere signal (tropospheric scatter signal), unstable high signal caused by reflection in elevated tropospheric layers, and stable high signal caused by ducting. The fact that the signals at different frequencies are only occasionally correlated indicates that the propagation is governed by different mechanisms in

different parts of the frequency spectrum. A case study of propagation under various tropospheric conditions and the long term statistics of the different signal types are given. Author

**N74-13864** Communications Research Centre, Ottawa (Ontario)

**INTERFERENCE MEASUREMENTS AT 15.7 GHz OVER A LONG TRANSHORIZON PATH**

R. L. Olsen and U. H. W. Lammers. In AGARD Propagation Effects of Freq Sharing Sep 1973 15 p refs. Prepared in cooperation with AFCRL, H. G. Hanscom Field, Mass. (For availability see N74-13846 05-07)

Experiments are being carried out to obtain transmission loss statistics for 500 km overland path at 15.7 GHz. The interference situation simulated is that of a terrestrial transmitter interfering into the earth terminal receiver of a space communications system along the great circle path between them or at off path angles close to the great circle azimuth. The initial results of measurements over a six month period indicate that, for this path, the empirical method underestimates the transmission loss not exceeded for small percentages of the time by an amount which increases with the elevation angle of the earth station antenna. Additional analysis is also being carried out to determine the relative occurrences of turbulent scattering, hydrometeor scatter (including cloud scatter), and ducting, and to separate the data accordingly. Author

**N74-13865** GEC-Marconi Electronics Ltd., Chelmsford (England)

**TROPOSCATTER PROPAGATION IN AN EQUATORIAL CLIMATE**

R. Larson. In AGARD Propagation Effects of Freq Sharing Sep 1973 9 p refs. Sponsored by the Min of Defence. (For availability see N74-13846 05-07)

A troposcatter link between Singapore and Penang was operated for almost two years. During this time continuous analogue recordings of received signal strength were made, and meteorological measurements were also made at both ends of the link. The radiometeorology proved to be very stable and was an excellent example of equatorial type climate. The measured median signal level was very close to the predicted value and also the hourly median signal levels followed a log-normal distribution with great fidelity, even to extreme percentage levels, both high and low. Consideration of the available data led to the conclusion that there was no evidence of any ducting at all, a pure scatter signal being received throughout. Fast fading records indicated that even at the highest signal levels a Rayleigh fading signal was present and the log-normal and Rayleigh distributions have been combined to produce an overall distribution of instantaneous signal level. Author

**N74-13866** Radio and Space Research Station, Slough (England)

**STATISTICS OF HIGH-LEVEL BEYOND-HORIZON SIGNALS AT 2.2 GHz AND 2.6 GHz AND MEASUREMENTS OF THE VARIATION OF THE ARRIVAL-ANGLE-STRUCTURE**

M. P. M. Hall. In AGARD Propagation Effects of Freq Sharing Sep 1973 10 p refs. (For availability see N74-13846 05-07)

Continuous recordings of field strength were made simultaneously over two 300 km troposcatter paths, one over land at 2.6 GHz and the other partly over sea at 2.2 GHz. The recordings were made on 1.2 m diameter antennae at Chilbolton (near Winchester UK). Periodically, the 25 m diameter steerable antenna was used to scan across the paths in bearing and elevation to determine the angular distribution of the arriving energy. An analysis is presented of the high signal strengths exceeded for small percentages of the time, of the relative duration of these enhancement periods, and of the changes in angular spread which occurred as the high signals built up and died away. Results from an analysis of the cross correlation of the outputs from large and small antennas are presented in order to determine if phase cancellation of unwanted interference may be feasible during periods when interference signals on troposcatter paths become unacceptable high. Author

**N74-13867** Scripps Institution of Oceanography, La Jolla, Calif.

**HF MEASUREMENTS OF OCEAN-WAVE DIRECTIONAL SPECTRA**

Robert H. Stewart, Calvin Teague, Joseph W. Joy, and G. Leonard Tyler. In AGARD Propagation Effects of Freq Sharing Sep 1973 7 p refs. Prepared in cooperation with Stanford Univ. (For availability see N74-13843 05-07) (Contract N00014-69-A-0200 6012)

Bragg scattered HF radio waves were used to measure the directional spectrum of 0.14 Hz ocean waves during a time when they were in equilibrium with a constant and spatially homogeneous wind field. The radio data consisted of monostatic measurements of LCIAN A radio signals backscattered from the ocean. These signals are pulsed, coherent, and vertically polarized and are resonantly scattered only by 0.14 Hz ocean waves moving radially toward or away from the transmitter/receiver point. The direction of arrival of the radio waves, and thus the directional distribution of the ocean wave energy, was determined by synthesizing a directional antenna having a maximum beamwidth of 5.10 deg. The synthesis was done by moving the receiver along two nearly orthogonal paths using the runway and taxiways of the island. The right-left ambiguity in the synthesized antenna was resolved by using a switched cardioid antenna which looked alternately to the right and the left as the basic receiving element. The angular dependence of the ocean wave directional spectrum is presented as a function of wind speed. Author

**N74-13868** Hamburg Univ. (West Germany) Inst fuer Radiometeorologie und Maritime Meteorologie

**EXPLANATION OF VERY LOW FIELD STRENGTH LEVELS ON LINE-OF-SIGHT PATHS OVER SEA**

H. W. Fruechtenicht. In AGARD Propagation Effects of Freq Sharing Sep 1973 12 p refs. (For availability see N74-13846 05-07)

Line of sight propagation over sea may be treated by ray tracing. The method is applied to linear profiles and duct profiles of the refractive index. The model calculation shows that the receiving field passes through a number of interference lobes if the duct thickness is increased. This effect is verified by experiments. Furthermore, the theoretical considerations yield that the sea evaporation duct causes a certain antenna height, where the receiving field may vanish. With increasing duct thickness, this special receiving point is shifted upwards. Vertical polarization puts it on a lower level than horizontal polarization. Moreover, with increasing duct thickness it is shifted upwards more slowly for vertical polarization than for horizontal polarization. Author

**N74-13869** Servico de Telecomunicacoes Militares, Lisbon (Portugal)

**ANALYSIS OF 11 GHz BAND PROPAGATION IN PORTUGAL**

J. A. Saraiva Mendes. In AGARD Propagation Effects of Freq Sharing Sep 1973 8 p refs. (For availability see N74-13846 05-07)

Supplemental attenuation due to rain at 11 GHz on paths 20 km long in different places of Portugal is estimated. The cumulative distributions of clock hourly rain rates for Lisbon, Oporto and Coimbra are calculated and compared with those obtained directly from climatic data using the method proposed by Russak and Easley. Then using the methods proposed by Quarta and by Boithias et al. the cumulative distributions of instantaneous attenuation due to rain are also calculated for Lisbon, Oporto and Coimbra. The results obtained with both methods are compared and discussed. It seems that the method proposed by Boithias et al. cannot be widely used in Portugal. However, the reduction coefficients proposed by Boithias et al. in order to obtain the equivalent rain rate along a path lead to distributions similar to those obtained with the method proposed by Quarta. The estimated supplemental attenuation in a path 20 km long at 11 GHz is about 35 dB for 0.001% of the year and for paths orthogonal to the dominant winds. Author

**N74-13870** Department of Transportation, Cambridge Mass  
**MEASUREMENT OF ATMOSPHERIC ATTENUATION AT  
 THE FREQUENCIES OF 16, 19, AND 34 GHz**

George G Haroules, Wilfred E Brown, and Gregory J Bishop  
 In AGARD Propagation Effects of Freq Sharing Sep 1973

14 p refs (For availability see N74-13848 05-07)

There are two methods of determining atmospheric attenuation without having to use a space vehicle. In the first, attenuation may be measured by observing the extinction of an exoatmospheric source as a function of the zenith angle. The second method depends upon the measurement of atmospheric emission from which the corresponding attenuation is calculated using an assumed atmospheric mean temperature. The magnitude of atmospheric attenuation and the relative time interval of its occurrence at millimeter wavelengths must include consideration of the elevation angle of observation. Knowledge of the percentage of time during which relatively high values of attenuation are observed is irrelevant without consideration of the elevation angle of observation at the time of occurrence. Attenuation statistics resulting from a twelve month observation program are presented. The sun is used as a source of microwave radiation. The dynamic range of atmospheric attenuation measurement capability is in excess of 30 db. Author

**N74-13871** Army Satellite Communications Agency Fort  
 Monmouth, NJ

**THE INTERRELATION OF PROPAGATION EFFECTS AND  
 DESIGN FACTORS FOR FIXED SERVICE COMMUNICA-  
 TIONS SATELLITE SYSTEMS**

Billy J Fansler and S M Segner. In AGARD Propagation  
 Effects of Freq Sharing Sep 1973 11 p refs. Prepared in  
 cooperation with ECUM, Ft Monmouth, N J. (For availability  
 see N74-13848 05-07)

The problems of frequency sharing between multichannel transmission using satellites and multichannel transmission using radio relay are reviewed. Two cases of potential interference involve determination of coordination distance based on normalized basic transmission in the absence and in the presence of precipitation. One case is for the earth station received signal being interfered with by terrestrial station transmitters. The second is for earth station transmitted signal interfering with terrestrial station receivers. Taking advantage of a newly written computer program, the effects of varying propagation factors, radio climatic regions, rain climatic zones and interference duration is investigated. Author

**X74 73498** Advisory Group for Aerospace Research and  
 Development Paris (France)

**THE IDENTIFICATION OF MILITARY UTILIZATION OF  
 FREQUENCY BANDS ABOVE 10 GHz**

H J Albrecht Jul 1972 68 p

(AGARD AR 42)

NATO Restricted Report

The radio frequency spectrum below 10 GHz is rapidly reaching saturation. National Authorities are actively considering a revision of the international allocation of the spectrum above 10 GHz. In order that NATO Military Authorities may assure the satisfaction of NATO wide military requirements and be supported by adequate technical knowledge, an overall NATO evaluation of the propagation parameters affecting the use of the spectrum above 10 GHz was necessary and is presented in this report.

**X74 73499** Advisory Group for Aerospace Research and  
 Development Paris (France)

**THE IDENTIFICATION OF MILITARY UTILIZATION OF  
 FREQUENCY BANDS ABOVE 10 GHz**

H J Albrecht ed Jun 1973 52 p Revised

(AGARD AR 42 Rev)

NATO Restricted Report

For abstract see X74 73498



## 08 COMPUTERS

Includes computer operation and programming, and data processing. For applications, see specific categories. For related information see also 19 Mathematics

**N72-11174#** Advisory Group for Aerospace Research and Development, Paris (France)  
**ARTIFICIAL INTELLIGENCE**

Thomas G. Evans, ed. Sep 1971 324 p. refs. Presented at AGARD Avionics Panel Tech Symp on Artificial Intelligence, Rome, 24-28 May 1971

(AGARD-CP-94-71) Avail NTIS HC \$6.00; MF \$0.95

The conference papers on artificial intelligence with emphasis on pattern recognition is reported. Other areas covered were robotics and robot vision, question-answering, natural language and speech recognition and man-machine interactive problem solving.

**N72-11176#** Grumman Aerospace Corp., Bethpage, NY  
**ESTABLISHING REQUIREMENTS FOR ARTIFICIAL INTELLIGENCE IN THE AIRBORNE AND SPACE ENVIRONMENTS**

Robert S. Aha. In AGARD Artificial Intelligence Sep 1971 9 p. refs. (See N72-11174 02-08)

Avail NTIS HC \$6.00; MF \$0.95

Man-machine comparisons and basic requirement parameters for those most crucial operational problems for airborne, space, and non-terrain operations, wherein man must make use of artificial intelligence techniques, are delineated. Operational areas discussed are: safety of flight in flying close to the earth; missions for surveillance and reconnaissance operations; aircraft control in the vicinity of airports; space shuttle docking; and other critical operations.

Author

**N72-11178#** Washington Univ., St. Louis, Mo. Dept. of Applied Mathematics and Computer Science  
**ROBOT DATA SCREENING: AN INTELLIGENT (?) DATA SEARCH TECHNIQUE**

Theodor D. Sterling. In AGARD Artificial Intelligence Sep 1971 8 p. refs. (See N72-11174 02-08)

Avail NTIS HC \$6.00; MF \$0.95

The process of robot data screening is described and an evaluation is made of its potential as a possible heuristic procedure to aid in sorting out the most important features in an aggregate of empirical observations. Robot screening uses a measure of relevance of variables derived from the usefulness of variables to serve as predictors for the outcomes of observations. It is pointed out that, although probability of correct cross-classification is a satisfactory method, entropy constitutes a more suitable criteria for determining relevance. In robot screening, the entropy produced with each cross classification is examined and those that indicate the largest change in entropy are selected. Special tests are then applied to each variable or variable combinations to see if its use is an improvement over the use of no or fewer predictors. As a final step, a search algorithm provides a practical method to converge upon the more useful cross-classification variable combinations.

D. L. G.

**N72-11177#** Democritus Nuclear Research Center, Athens (Greece). Electronic Computers Div.  
**ON THE QUESTION ANSWERING SYSTEM DELFI AND ITS APPLICATION**

J. Kontos and A. Kossidas. In AGARD Artificial Intelligence Sep 1971 6 p. refs. (See N72-11174 02-08)

Avail NTIS HC \$6.00; MF \$0.95

The latest version of the question-answering system DELFI is described and examples of its application are given. DELFI is based on the automatic generation of programs that express the meaning of English-like sentences via a procedural intermediate language. The general characteristics of DELFI are: mass storage

data-base, variety of application, modular design and almost realistic scale of performance. The English-like sentences accepted by DELFI include statements, questions, commands, and conditional sentences. These sentences are parsed and translated by a grammar-directed semantic interpreter into programs in a high-level procedural language composed from procedural semantic components. The procedural semantic components used perform operations which are of logical, set processing, data flow control and program flow control kind respectively. The programs generated have access to the data-base for updating and retrieval. Examples of application of DELFI are given in data management, picture processing and simple problem solving.

Author

**N72-11178#** IBM Italia, Rome

**AN APPROACH TO NATURAL LANGUAGE FOR COMMAND AND CONTROL SYSTEMS**

A. Lanzetta. In AGARD Artificial Intelligence Sep 1971 9 p. refs. (See N72-11174 02-08)

Avail NTIS HC \$6.00; MF \$0.95

The feasibility was examined of defining a highly user-oriented language, as close as possible to a natural language, for command and control systems. Several different language models were analyzed. Because of the recognized difficulty of computer programs to fully understand a natural language, the study goal was changed to the identification of a habitual language. The suitability of different models to describe the habitual language is discussed and the most promising model is selected. Possible methodology to be used to tailor the model to a particular command and control environment is also discussed.

D. L. G.

**N72-11179#** Rome Air Development Center, Griffiss AFB, NY  
**AUTOMATIC SPEAKER RECOGNITION SYSTEMS**

Bruno Beek, James Grech, and Willard F. Meeker (RCA Camden, N. J.). In AGARD Artificial Intelligence Sep 1971 7 p. refs. (See N72-11174 02-08)

Avail NTIS HC \$6.00; MF \$0.95

Two systems, with variations, for speaker recognition are described. The recognition decisions are made automatically from continuous speech uncontrolled as to context. One system uses primarily pitch and spectral characteristics obtained from voiced sounds. The other system employs automatic speech recognition circuitry to extract phonemes so that the spectral characteristics of each phoneme type can be tabulated separately. The characteristic manner in which individual phonemes are pronounced by different speakers is used to identify or differentiate between speakers. Results obtained with 30 speakers are presented.

Author

**N72-11180#** National Research Council of Canada, Ottawa (Ontario). Control Systems Lab.

**EXPERIMENTS WITH A HEURISTIC ON-LINE PICTURE PROCESSING LANGUAGE**

T. Keeney. In AGARD Artificial Intelligence Sep 1971 6 p. (See N72-11174 02-08)

Avail NTIS HC \$6.00; MF \$0.95

A short description of a heuristic picture processing, learning and recognition system is outlined. It is shown that it is possible to construct a pattern recognition system which is independent of picture content. The objects in the picture are fragmented (if they are complicated) descriptions for the fragments (atoms) are formed and normalized before they are recognized. The interrelationships between the atoms composing an object are stored. During recognition these interrelationships are used in a procedure resembling hypotheses testing. A simplified version of the proposed system was programmed and gave adequate results.

Author

**N72-11181#** Communications Research Centre, Ottawa (Ontario)

**WEATHER RADAR IMAGE PROCESSING**

A W Bridgewater. In AGARD Artificial Intelligence Sep 1971 13 p refs (See N72-11174 02-08)  
 Avail NTIS HC \$6.00 MF \$0.95

The use is explored of computer image-processing for feature extraction in PPI displays of radar backscatter. The picture is transformed or "processed" in order to reveal to the human analyst certain structural parameters of the patterns which are not directly accessible by visual inspection. Once identified, these parameters are extracted automatically and summary statistics of precipitation characteristics can be built up for long sequences of pictures. In the search for suitable features to describe the attenuation phenomena, the two-dimensional autocorrelation function of the image is shown to be useful. It is implemented digitally using the fast Fourier transform algorithm and it results in relatively regular, smoothly contoured structures which indicate average measures of ellipticity, directivity, periodicity, and correlation distances of the echo patterns. Data reduction methods for quantifying and extracting these features are described. Author

N72-11182# Plessey Co. Ltd. Havant (England) Electronics Research Lab

**A PRACTICAL APPLICATION OF PATTERN RECOGNITION**  
 C J W Mason and O E Morgan. In AGARD Artificial Intelligence Sep 1971 8 p ref (See N72-11174 02-08)  
 Avail NTIS HC \$6.00 MF \$0.95

A study was made of the application of pattern recognition techniques, using partitioning of data in n-space, to the detection of personnel who may be moving at a rate comparable with that of a clutter-producing environment. The sensor employed was a Doppler radar. Details of the processing and results are given. Feasibility of the techniques is demonstrated. Author

N72-11183# Transportation Systems Center, Cambridge Mass.  
**AUTOMATIC DETECTION OF VEHICLES IN AERIAL PHOTOGRAPHS OF HIGHWAYS**

Juris G Raudasnis. In AGARD Artificial Intelligence Sep 1971 8 p (See N72-11174 02-08)  
 Avail NTIS HC \$6.00 MF \$0.95

The problem of time and effort involved in the data reduction process with information obtained through aerial photographs of highways is dealt with. An approach to automating the data reduction process is described. Techniques from the fields of interactive computer graphics and automatic pattern recognition are used in combination to reduce the amount of human effort required. A computer - controlled flying - spot scanner is used to scan the photographs. By means of a graphics tablet and stylus, a human operator selects ground reference points, delineates road boundaries, and may mark vehicles. The computer extrapolates the trajectories of vehicles to predict their positions in successive photographs. Their precise locations are then determined and recorded by applying pattern recognition techniques, matching the vehicle images in the current frame against their recorded images in the previous frame of photography. Author

N72-11184# Purdue Univ. Lafayette Ind. School of Electrical Engineering

**AUTOMATIC MEDICAL DIAGNOSIS USING NONPARAMETRIC SEQUENTIAL CLASSIFICATION PROCEDURES**  
 K S Fu and M H Loew. In AGARD Artificial Intelligence Sep 1971 9 p refs (See N72-11174 02-08)  
 (Grant AF-AFOSR-1776-69)  
 Avail NTIS HC \$6.00 MF \$0.95

Two nonparametric sequential classification procedures are applied to medical diagnosis problems. The procedures include: (1) sequential classification using nonparametric partition, and (2) sequential classification using nonparametric ranking. Specific results of some real-time medical diagnosis are presented for the problems of separating primary liver cancer from primary cancer of the pancreas, and for the separation of those from normal cases. The measurements (features) used are blood chemistry and hematology values, urinalysis, X-ray and liver scan results.

and ECG and EEG analysis. Classifications for the training data were determined according to the patients' most recent diagnosis, either by biopsy at surgery or pathology at autopsy. The results obtained from these two proposed procedures are compared and their corresponding advantages and disadvantages are discussed. Author

N72-11185# Bunker-Ramo Corp. Westlake Village Calif.  
**FIXED AND ADAPTIVE ALGORITHMS FOR PATTERN RECOGNITION: PROBLEMS IN THEORY AND APPLICATION**

C M Bartone and F A Muckler (Manned Systems Sci. Inc.) In AGARD Artificial Intelligence Sep 1971 13 p refs (See N72-11174 02-08)  
 Avail NTIS HC \$6.00 MF \$0.95

Based on recent Soviet and American theoretical developments, information is presented on adaptive and self-organizing algorithms and problems in applications, specifically in multiple sensor input processing and voice encoding. In addition, detailed descriptions are given of Soviet work in computer-aided medical diagnostics. Author

N72-11186# Carnegie-Mellon Univ. Pittsburgh, Pa. Dept. of Computer Science

**COMPUTER PROCESSING OF NATURAL SCENES: SOME UNSOLVED PROBLEMS**

Ugo Montanari (CNR, Pisa, Italy) and Raj Reddy. In AGARD Artificial Intelligence Sep 1971 5 p refs (See N72-11174 02-08)  
 (Contract F44620-70-C-0107)  
 Avail NTIS HC \$6.00 MF \$0.95

The problem is considered of extending the present methods used in visual image processing to the analysis of natural scenes. The limitations are discussed of presently used techniques such as edge detection algorithms, two-dimensional Fourier transforms and linguistic methods. In addition, recommendations are proposed for future research in processes which appear to be promising. D L G

N72-11187# Consiglio Nazionale delle Ricerche, Rome (Italy)  
**KINEMATIC ASPECTS OF PROJECT OF UNCONVENTIONAL LOCOMOTION VEHICLES**

T Leo and R Vitelli. In AGARD Artificial Intelligence Sep 1971 10 p refs (See N72-11174 02-08)  
 Avail NTIS HC \$6.00 MF \$0.95

The development is reported of an unconventional locomotion vehicle, capable of moving on jointed legs and performing rectilinear displacements on an horizontal plane. Movement is automatically controlled by input signals but the degree of control is limited to translational speed. The problem considered involves the additional development of a steering control system. A theoretical study is described in which a heuristic approach to the problem is taken. The minimum possible number of degrees of freedom are used and stability conditions of vehicle motion and other given constraints on locomotion are respected. In addition, complete automation of the vehicle is maintained. D L G

N72-11188# Aerojet-General Corp. Azusa Calif.  
**RECOGNIZING THREE DIMENSIONAL OBJECTS BY THEIR SILHOUETTES**

J Sklensky and G A Davison, Jr. In AGARD Artificial Intelligence Sep 1971 11 p refs. Prepared in cooperation with Calif. Univ. Irvine (See N72-11174 02-08)  
 (Contract F33615-69-C-1314)  
 Avail NTIS HC \$6.00 MF \$0.95

A method is described for classifying or identifying a three-dimensional object from one or more of its silhouettes. The method is based on a low-cost parallel mechanism for computing the slope density of the edge of the silhouette. The proposed technique computes the slope density by a circularly rotating array of photodiodes. The slope density is then passed through a set of narrow-band-pass filters, yielding the Fourier harmonics of the slope density. In order to take account of varying aspect angles of the original object, the object is

represented by a number of prototypes, each prototype being a vector of the Fourier harmonics of the slope density. These prototypes appear in a decision tree that makes the final recognition. An experimental machine implementing this technique is described, and the results obtained with the machine for recognizing five classes of aircraft are given. Author

**N72-11189# Texas Univ. Austin, Dept of Electrical Engineering  
SEQUENTIAL STRUCTURE AND PARAMETER ADAPTIVE  
PATTERN RECOGNITION. PART 1. SUPERVISED  
LEARNING**

D. G. Lainiotis. In AGARD Artificial Intelligence. Sep 1971. 11 p. refs. (See N72-11174 02-08)  
(Grants AF-AFOSR-1764-69, AF-AFOSR-0768-67E)  
Avail. NTIS HC \$6.00/MF \$0.95

Recursive filters for supervised learning Bayes-optimal adaptive pattern recognition with continuous data are derived. Both off-line (or prior to actual operation) and on-line (while in operation) supervised learning is considered. The concept of structure adaptation is introduced and both structure as well as parameter adaptive optimal pattern recognition systems are obtained. Specifically, for the class of supervised learning pattern recognition problems with Gaussian process models and linear dynamics, the adaptive pattern recognition systems are shown to be decomposable into a linear, non-adaptive part consisting of recursive, matched Kalman filters, a nonlinear part consisting of a set of probability computers that incorporates the adaptive nature of the system, and finally a linear part of the correlator-estimator form. Extensions of the above results to the M-ary hypotheses cases, where  $M > 0$  or  $2$  are given. Author

**N72-11190# North American Rockwell Corp., Thousand Oaks, Calif. Science Center**

**SEMI-ADAPTIVE APPROACH TO PATTERN RECOGNITION**  
John M. Richardson. In AGARD Artificial Intelligence. Sep 1971. 7 p. refs. (See N72-11174 02-08)

Avail. NTIS HC \$6.00/MF \$0.95

Two kinds of approaches to pattern recognition, representing extreme limits of the adaptive-nonadaptive axis, are considered. These include: (1) the adaptive approach in which the prior information is composed mainly of pre-classified training patterns with a very limited amount of information designed into the system, and (2) the nonadaptive approach in which the prior information is composed entirely of information designed into the system. Emphasis is placed on deriving some intermediate approaches by combining various aspects of the two described approaches. The methodology employed involves the use of mathematical models of pattern classes to which decision theory is applied. The models, although stochastic, are partially indeterminate in the sense that some of the probability parameters are not completely known. In the adaption phase both Bayesian and non-Bayesian techniques are considered for the reduction of model indeterminacy through pre-classified samples. D.L.G.

**N72-11191# Manufacture Belge de Lampes et de Materiel Electronique, Brussels (Belgium)**

**A GENERAL ORDER MINKOWSKI METRIC PATTERN CLASSIFIER**

Pierre A. Devijver. In AGARD Artificial Intelligence. Sep 1971. 11 p. refs. (See N72-11174 02-08)

Avail. NTIS \$6.00/MF \$0.95

One general category of multiclass deterministic pattern recognition systems is defined by a linear structure in the input variables and an analytical criterion. This criterion requires the minimization of the average pth power of one Minkowski distance measure of order p in one particular decision space. Analytical reasoning indicates that the criterion yields an error-correcting procedure. The procedure results in a reduction of the number of misclassifications when the order of the criterion metric is increased. This feature renders the criterion

particularly well suited to nonseparable problems. It is briefly mentioned how this design criterion may be used to produce optimized decision surfaces in the separable two class case, as it tends to maximize the minimum distance from each class to the decision surface. The Bayesian distribution-free classifier appears as a special case of the general category of classifiers defined by the criterion. Author

**N72-11192# Florida Univ., Gainesville. Center for Informatics Research**

**PREPROCESSING FOR PICTORIAL PATTERN RECOGNITION**

R. H. Cofer and J. T. Tou. In AGARD Artificial Intelligence. Sep 1971. 13 p. refs. (See N72-11174 02-08)

(Contract N00014-68-A-0173-0001)

Avail. NTIS HC \$6.00/MF \$0.95

An integrated preprocessing system is presented for the purpose of line extraction. This system consists of six stages, each of which reduces an abstract, i.e. defined, line network of a picture to a form which represents the physical line structure more meaningfully or efficiently. In operation, the picture is first stripped of all spurious objects and holes. A connected medial axis is then found for each object in order to reduce the line width. This is followed by removal of all 4-point loops, resulting everywhere in abstract lines of unit thickness. Noise branches a natural result of the prior processing technique are then removed. For greater processing flexibility the abstract line structure is then inserted into a list data structure composed of line, junction, and endpoint entries. The resulting structure is then further processed in order to improve the representation of those junctions of many lines. The final representation of the picture serves as an ordered, high level data base upon which further pattern analysis, recognition, or processing may be conducted. Author

**N72-11193# Philips Gloeilampenfabrieken N. V., Eindhoven (Netherlands)**

**A NAIVE METHOD FOR MACHINE RECOGNITION OF HAND WRITTEN NUMERALS**

M. Beun. In AGARD Artificial Intelligence. Sep 1971. 10 p. refs. (See N72-11174 02-08)

Avail. NTIS HC \$6.00/MF \$0.95

A method for character recognition by machines is described. The character to be recognized is scanned to obtain a matrix of black and white dots, to which a thinning process is then applied. This process, which has built in a precaution not to destroy connectivity, produces a skeleton of which no further point can be removed without either destroying connectivity or eating away end points. Features as end points and junctions are now readily detected and their occurrence and relative positions provide the basis of a recognition scheme. The recognition scheme is so made up that more and finer recognition criteria can be added when needed, without basically affecting the recognition possibilities already attained. Moreover, as more experience is gained as to the most effective criteria, a completely fresh start often produces a new recognition scheme that is simpler and more powerful than its predecessors. Author

**N72-11194# Siemens AG, Munich (West Germany)**

**HOLOGRAPHIC PATTERN RECOGNITION USING A MULTICHANNEL CORRELATOR**

G. Winzer and N. Douklias. In AGARD Artificial Intelligence. Sep 1971. 12 p. refs. Sponsored by Bundesministerium für Bildung und Wissenschaft. (See N72-11174 02-08)

Avail. NTIS HC \$6.00/MF \$0.95

A multichannel correlator for holographic matched filtering is described. The channels are separated spatially in the Fourier-plane. This arrangement allows individual filters to be realized for each channel for different spatial frequency ranges etc. The multichannel correlator is addressed by a generator of multiple object waves, i.e. by different directions of object illumination. Parallel and sequential evaluation of the correlation signals is possible. The efficiency and signal-to-noise ratio for

both modes of operation are discussed. In each channel linear superimposed multiple Vander-Lugt filters may be introduced to increase the overall capacity of learning steps. The risk of overexposure is very small because the centers of the frequency spectra are separated on the hologram filter plate. With a multichannel correlator combined matched and feature filtering may be performed. Preliminary experimental results show that this method can be successfully used in some cases where the results of simple matched filtering remain unsatisfactory. The results and discussions are presented from a more general point of view with some remarks concerning comparable methods and possible future aspects. Author

**N72-11195#** Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e. V., Karlsruhe (West Germany). Inst fuer Informationsverarbeitung  
**OPTICAL PATTERN PROCESSING FOR RECOGNITION**  
E. Muehlhaufeld. In AGARD Artificial Intelligence Sep 1971 7 p. refs (See N72-11174 02-08)  
Avail NTIS HC \$6.00 MF \$0.95

Optical processing is discussed as a useful tool for compressing pattern information by feature extraction. Topics discussed include: compression of pattern information; recognition of pattern vectors; and parallel processing. F O S

**N72-11196#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst fuer Satellitenelektronik  
**AN IMAGE PROCESSING AND PATTERN RECOGNITION SYSTEM FOR TIME VARIANT IMAGES USING TV CAMERAS AND A MATRIX COMPUTER**  
Ernst E. Trondl. In AGARD Artificial Intelligence Sep 1971 10 p. (See N72-11174 02-08)  
Avail NTIS HC \$6.00 MF \$0.95

An artificial visual system is discussed with desirable characteristics similar to those of a mammalian visual system. The general structure is described and includes: sensors; cameras; video reduction and input to the matrix processor; and master computer. F O S

**N72-11197#** Technische Hogeschool, Delft (Netherlands)  
**THE STORAGE OF VIDEO INFORMATION IN A MEMORY**  
P. H. T. VanDerMeer. In AGARD Artificial Intelligence Sep 1971 7 p. refs (See N72-11174 02-08)  
Avail NTIS HC \$6.00 MF \$0.95

The basic principles of the video-to-digital converter for storage of video information with small memory systems are presented. A composite video signal generated by the TV camera is considered to be made up of a brightness and a synchronization signal. The output of the converter consists of the brightness in a binary form, which is transferred to the core memory of a PDP 9 computer. Information reduction and compression limit the number of memory places required for storage of TV images. F O S

**N72-11198#** University Coll., London (England). Dept. of Physics  
**CELLULAR LOGIC AND ITS SIGNIFICANCE IN PATTERN RECOGNITION**  
M. J. B. Duff. In AGARD Artificial Intelligence Sep 1971 13 p. refs (See N72-11174 02-08)  
Avail NTIS HC \$6.00 MF \$0.95

The use of cellular logic in the solution of pattern recognition problems is discussed. Two classes of cellular logic arrays were investigated for pattern preprocessing. The class consists of variable function arrays with nearest neighbor connection and the other depends on switching circuits linked by diodes. F O S

**N72-11199#** Vanderbilt Univ., Nashville, Tenn.  
**A MAN-MACHINE APPROACH TOWARD SOLVING VARIOUS ROUTING, SCHEDULING, AND NETWORK PROBLEMS**

Patrick Krolak, Wayne Felts, and James M. Nelson. In AGARD Artificial Intelligence Sep 1971 12 p. refs (See N72-11174 02-08)  
(Grant NSF GK-4975)  
Avail NTIS HC \$6.00 MF \$0.95

A man-machine approach is presented for solving problems of the following types: traveling salesman; generalized truck dispatching; board wiring; and construction of minimum cost communication networks with survival or redundancy demands. The truck dispatching problem is considered in detail, and the man-machine process, data organization, computer heuristics, and the interactive phase are discussed. F O S

**N72-11200#** Bell Aerospace Co., Buffalo, N.Y.  
**PROCESSING AND DISPLAY OF TIME VARYING SPECTRAL INFORMATION WITH APPLICATION TO SONAR, VOICE, AND MEDICAL SIGNALS**  
Lester A. Gerhardt. In AGARD Artificial Intelligence Sep 1971 12 p. refs. Prepared in cooperation with Rensselaer Polytech Inst. (See N72-11174 02-08)  
(Contract AF 49(638)-1627)  
Avail NTIS HC \$6.00 MF \$0.95

The representation of a nonstationary signal by a time varying spectral display (TVSD) is described. Methods of generating the information used in a TVSD are discussed, with emphasis on on-line real time techniques. Several methods of displaying this information are presented, including computer and television generated images. General examples of processing the time varying spectral data are given with respect to periodic and aperiodic signal features. The applications of the TVSD are also presented. Selected research in the fields of Sonar, Voice, and Medical signal processing is discussed. The usefulness of the TVSD is demonstrated by examples using the loferogram voiceprint and phonocardiogram in each of these three fields respectively. Author

**N72-11201#** General Electric Co., Syracuse, N.Y.  
**SIGNAL ANALYSIS AND CLASSIFICATION BY INTERACTIVE COMPUTER GRAPHICS**  
A. W. Whitney and W. E. Bissell. In AGARD Artificial Intelligence Sep 1971 10 p. refs (See N72-11174 02-08)  
(Contract F30602-69-C-0227)  
Avail NTIS HC \$5.00 MF \$0.95

Many aspects of signal analysis and classification are briefly discussed and techniques are given for employing an interactive computer graphics facility to design signal classification systems. The signal classification problems addressed are characterized by the fact that the classification information present in the signals must be extracted from a limited number of identified signals. Author

**N72-11202#** Rome Air Development Center, Griffiss AFB, N.Y.  
**ON THE DESIGN OF WAVEFORM CLASSIFICATION SYSTEMS BY INTERACTIVE MAN-MACHINE METHODS**  
H. E. Webb Jr. and D. H. Foley. In AGARD Artificial Intelligence Sep 1971 19 p. refs (See N72-11174 02-08)  
Avail NTIS HC \$6.00 MF \$0.95

A waveform processing system is proposed for feature extractor design. The editing transformation, basic function expansion, digital filtering, and local feature operation are described. An on-line pattern analysis and recognition system is also discussed as a research tool for aiding analysts in designing classification logic. Author

**N72-11203#** International Computers Ltd., Kidsgrove (England)  
**NEW TECHNIQUES IN INTERACTIVE GRAPHIC CONSOLE DESIGN FACILITATING THE PRESENTATION AND MANIPULATION OF COMPLEX DATA**  
G. Hughes. In AGARD Artificial Intelligence Sep 1971 9 p. refs (See N72-11174 02-08)  
Avail NTIS HC \$6.00 MF \$0.95

An experimental method by which the techniques of interactive line graphics may be extended to the handling of

pictorial data is described. This involves a combination of a new storage scan converter with conventional digital incremental computational techniques. Indications are made as to how the method may be applied to pattern recognition and visual artificial intelligence problems and the manner in which the system may be enhanced to cater for color pictures is outlined. In addition to the above enhancements to cater for picture manipulation an enumeration of the problems in display presentation of pictorial data in an interactive terminal and a potential method of enhancement is briefly described. Author

**N72-11204#** Compagnie Generale de Telegraphie sans Fil, Paris (France)

**DIGITAL FILTERING PROCEDURES FOR A LINE IMAGE (PROCEDES DE FILTRAGE DIGITAL D'UNE IMAGE DE LIGNES)**

J. C. Simon and A. Checrout. In AGARD Artificial Intelligence Sep 1971. 14 p. refs. In FRENCH-ENGLISH summary. (See N72-11174 02-08)

Avail. NTIS HC \$6.00 MF \$0.95

The use of computers to analyze data which modifies the usual representation concepts are discussed. The following constraints introduced by computers are analyzed: digitization, memory size, and algorithmic treatments. An adaptation of the conventional filtering processes of an image leads to digital filters, which are well suited to arithmetic computation. These principles are applied to the optimal storage of an image, to the reduction of information volume, and to the first level features extractions. The PPI radar information is processed by these methods. The aim is to reduce the available information to a few specific features that will describe a radar situation. Hill ridges are such features. They are automatically extracted and represented by lines, which are then coded and stored. Author

**N72-11205#** Karlsruhe Univ. (West Germany). Inst. for Inform. and Transmission

**GENERATION OF LINE DRAWINGS FROM GREY-SCALE PICTURES**

F. Holdermann and H. Kazmierczak. In AGARD Artificial Intelligence Sep 1971. 14 p. refs. (See N72-11174 02-08)

Avail. NTIS HC \$6.00 MF \$0.95

The problem of detecting boundaries of objects in gray scale pictures is studied. An object is defined as a region with a reasonable uniform distribution of intensities. Three methods are presented and the results of their applications to some aerial photos are discussed. The detected boundaries are given by differential line elements which are described in each picture point by a direction, characterizing the orientation of the boundary and by a weight, characterizing the amount of the gradient of the intensity distribution. A filtering and a contour tracing algorithm, based on the direction and weight information of the boundaries are briefly discussed. Author

**N72-11206#** Technical Univ. of Denmark, Lyngby. Electronics Lab

**PATTERN RECOGNITION USING DYNAMIC PICTORIAL INFORMATION**

Peter W. Becker and Knud A. Nielson. In AGARD Artificial Intelligence Sep 1971. 6 p. refs. (See N72-11174 02-08)

Avail. NTIS HC \$6.00 MF \$0.95

Problem solving with man-machine interaction was considered for pattern recognition using both static and dynamic information. Topics discussed include: recognition of handprinted digits, recognition logic, dynamic attributes, and static attributes. It is concluded that the use of dynamic pictorial information simplifies recognition of picture patterns. F. O. S.

**N72-21211#** Advisory Group for Aerospace Research and Development, Paris (France)

**COMPUTERS IN THE GUIDANCE AND CONTROL OF AEROSPACE VEHICLES**

C. T. Leondes, ed. (Calif. Univ. Los Angeles) Feb 1972. 265 p. refs.

(AGARDograph-158, AGARD AG-158) Avail. NTIS

The utilization of computer technology in aerospace systems is examined in detail. Three major areas are considered: (1) system design techniques, (2) systems hardware techniques, and (3) guidance and control computer systems applications. For individual titles, see N72-21212 through N72-21227.

**N72-21212#** North American Rockwell Corp., Anaheim, Calif.  
**OVERVIEW OF AEROSPACE VEHICLE COMPUTER APPLICATIONS**

Gordon H. Smith. In AGARD Computers in the Guidance and Control of Aerospace Vehicles. Feb 1972. p. 1-7. (See N72-21211 12-08)

Avail. NTIS

A brief historical treatment is presented of the application of digital computing techniques to aerospace systems. The technological developments in both hardware and system application are summarized and the impact of new technologies is discussed. Problems which have developed in applying digital computers in real time control systems are identified along with successful solutions to those problems. Author

**N72-21213#** International Business Machines Corp., Owego, N.Y. Electronics Systems Center

**FEDERATED VS INTEGRATED COMPUTER SYSTEMS**

James H. Crenshaw. In AGARD Computers in the Guidance and Control of Aerospace Vehicles. Feb 1972. p. 9-22. refs. (See N72-21211 12-08)

Avail. NTIS

The computer system organizations utilized in current aerospace systems and design considerations for developmental systems are reviewed. The advantages and disadvantages of the federated and integrated approaches are analyzed and the system dependent variables which must be considered by the designer are discussed to emphasize the real world situation. Features such as vulnerability to battle damage and graceful degradation are considered along with the queuing theory, waiting time, and loading factor. Author

**N72-21214#** Teledyne Systems Co., Northridge, Calif.

**GUIDANCE AND CONTROL COMPUTER SYSTEM DESIGN**  
Earl Kanter. In AGARD Computers in the Guidance and Control of Aerospace Vehicles. Feb 1972. p. 23-43. (See N72-21211 12-08)

Avail. NTIS

The subject of logical organization of typical aerospace computers is considered from the standpoint of integrated circuit technology and architectural requirements. First a proposed circuit technology amenable to a flexible mechanization of modern architecture is presented. Then, two general classes of computer systems design are discussed, utilizing this circuit technology. The two general classes are represented by a special purpose guidance and control computer and a general purpose computer programmable for a guidance and control application. Author

**N72-21215#** North American Rockwell Corp., Downey, Calif.

**REAL TIME PROGRAMS FOR AEROSPACE VEHICLES**

Victor Strand and L. J. Andrews (IBM Corp., Huntsville, Ala.) In AGARD Computers in the Guidance and Control of Aerospace Vehicles. Feb 1972. p. 45-56. (See N72-21211 12-08)

Avail. NTIS

An overview is presented of the developmental and technical considerations associated with the generation and checkout of computer programs for real time control of aerospace vehicles. Technical topics include a discussion of executive programs, program growth, program modularity, fixed vs. floating point arithmetic, higher order languages, etc. The software preliminary and baseline designs, documentation, verification, validation, models, monitors and program management are discussed as they affect the production and checkout of real time aerospace software. A brief dissertation on future efforts and considerations is also presented. Author

**N72-21216#** Singer Librascope, Glendale, Calif  
**PROGRAMMING CHARACTERISTICS OF FUTURE G AND C COMPUTERS**

Austin J. Maher / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 57-63 refs (See N72-21211 12-08)

Avail NTIS

The types of difficulties encountered in developing and maintaining airborne computer programs are reviewed. These include problems encountered in the initial development of the system program and the significant changes to the original program based on laboratory and flight tests of the over-all system. By assimilating results of previous system development experience and predicting the trends in airborne computer hardware development, characteristics are proposed for future airborne Guidance and Control computers. The proposed computer characteristics would minimize significant programming difficulties while retaining desirable hardware features (e.g., protected memory, small size, etc.). The features covered include word length tradeoffs, type of arithmetic, addressing techniques, subprogram linkages, etc., and in summary represent a functional specification for a class of future airborne computers using MSI or LSI techniques. Finally, the specific characteristics are presented of an airborne computer designed to meet these functional specifications.

Author

**N72-21217#** International Business Machines Corp., Owego, N.Y. Electronics Systems Center

**AEROSPACE COMPUTER WORD LENGTH CONSIDERATIONS**

G. W. Braudaway and C. J. Standish / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 65-71 refs (See N72-21211 12-08)

Avail NTIS

A number of data word and instruction format factors are described which must be considered when selecting the length(s) of instructions and data words to be implemented in an aerospace computer. The primary emphasis is on selection of data-word and instruction lengths under the constraint that data and instruction lengths are compatible. This is, the data-word length is an integral multiple of the instruction word length. This implementation is appropriate when data and instructions are to be stored in the same area of memory. In a section devoted to storage efficiency, the effects on implementation of removing the compatibility constraint are examined. Examples drawn from avionics navigation computations are used to illustrate the premise that variable word length arithmetic can be used to produce numeric results equivalent to those produced by uniform word length arithmetic while reducing storage requirements substantially. Additional storage savings can result from use of variable length instruction formats. The need is demonstrated for continued development of programming techniques for utilizing variable word length arithmetic and instruction formats efficiently.

Author

**N72-21218#** Sperry Rand Corp., St. Paul, Minn. Univac Div  
**AEROSPACE COMPUTER MEMORY TECHNIQUES**

J. R. Erhardt, K. L. Pearson, W. S. Makos, and E. J. Torok / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 73-82 refs (See N72-21211 12-08)

Avail NTIS

Current avionics and aerospace memory technology are described, and the techniques available in today's production systems as well as those soon likely to be in production are reviewed. Three major categories are discussed: magnetic memories, semiconductor memories and mass memory applications of plated wire, and thin film and domain wall propagation techniques.

Author

**N72-21219#** Teledyne Systems Co., Northridge, Calif  
**AEROSPACE COMPUTER INPUT-OUTPUT TECHNIQUES**

P. K. Hammond and W. T. Palmer / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 83-91 (See N72-21211 12-08)

Avail NTIS

The design philosophy applied to the interfacing elements of an aerospace computer is discussed in terms of establishing the overall performance, reliability, maintainability, and cost of the system. Most of the key functional requirements which should be considered in the design phase of interfacing equipment are reviewed.

Author

**N72-21220#** Bendix Corp., Teterboro, N.J. Navigation and Control Div

**FAULT ISOLATION IN A DIGITAL GUIDANCE AND CONTROL COMPUTER**

David H. Blauvelt / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 93-98 (See N72-21211 12-08)

Avail NTIS

The possibility is examined of a general purpose digital computer being able to realize an optimum fault isolation capability in a guidance and control application. It is shown that if proper attention is given to the functional partitioning of the computer, self-test and self-diagnostic programs can be written which will determine that faults have occurred and will isolate them to the replaceable card level. It is also demonstrated that this can be accomplished with virtually no additional flight hardware and a relatively simple test console which allows maintenance personnel to communicate with the computer in question.

Author

**N72-21221#** Hughes Aircraft Co., Culver City, Calif. Aerospace Group

**GUIDANCE AND CONTROL COMPUTER ACTUATED DISPLAY SYSTEM TECHNIQUES**

G. K. Slocum, J. W. Gunvordahl, M. Wehrauch, and J. W. Weber / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 99-115 ref (See N72-21211 12-08)

Avail NTIS

The airborne computer is discussed in its relationship to the display systems it drives, and to the part that the crew plays in the management and control processes. These relationships are considered for current and near-term tactical aircraft systems with an outlook to the possibilities for the future.

Author

**N72-21222#** Teldix Luftfahrt-Ausrüstungs GmbH, Heidelberg (West Germany)

**SYSTEMS TASKS FOR ADVANCED AIRCRAFT NAVIGATION SYSTEMS**

F. G. Unger and R. S. Sindlinger / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 117-130 refs (See N72-21211 12-08)

Avail NTIS

Conventional navigation systems are described and compared with advanced systems proposed for military aircraft with instrumentation that would include an inertial platform, a Doppler radar, means for position fixing, and back-up devices such as air data units, magnetic compasses, etc. The additional tasks that would then be required of the navigation computer and data processing equipment are summarized. Possible hardware solutions are outlined and approaches to developing optimal equipment configurations are examined.

K. L. G.

**N72-21223#** Teledyne Systems Co., Northridge, Calif  
**HELICOPTER GUIDANCE AND CONTROL COMPUTER SYSTEMS**

Lawrence A. Kaufman / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 131-155 (See N72-21211 12-08)

Avail NTIS

The use of central digital computers for helicopter avionics

system functions is examined and it is shown how the use of such techniques has evolved as a consequence of the application of helicopters in increasingly more complex missions. The first of these new helicopter digital systems to be developed, the U.S. Marine Corps Integrated Helicopter Avionic System (IHAS), is described in terms of the conceptual design approaches used. The system synthesizes problems which are experienced using digital computation techniques are analyzed. Future trends for the application of central digital computers for both helicopters and VTOL aircraft are indicated. Author

**N72-21224#** Litton Systems, Inc., Woodland Hills, Calif. Guidance and Control Systems Div.  
**INTEGRATED INERTIAL DOPPLER LORAN COMPUTER GUIDANCE AND CONTROL**

Robert G. Berfield and William O. Felsman / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 157-174 (See N72-21211 12-08)

Avail NTIS

The navigation/guidance computer requirements for a typical, integrated inertial-Doppler-Loran mechanization are outlined, and the techniques are described for generating an efficient and accurate operational program. Author

**N72-21226#** ITT Avionics, Nutley, N.J.  
**COMPUTERS FOR LORAN C/D AND OMEGA NAVIGATION AND GUIDANCE SYSTEMS**

James P. VanEtten and Gerald P. Zemlin / In AGARD Computers in the Guidance Control of Aerospace Vehicles Feb. 1972 p 175-228 refs (See N72-21211 12-08)

Avail NTIS

A synopsis is given of geometry fundamentals pertinent to position-accuracy assessment, the fundamentals of both the Loran C/D and Omega systems (including technical summaries of low-frequency and very-low-frequency propagation), and the general effects of vehicle dynamics on system implementation. The application of the modern airborne digital computer to radio navigation signal processing tasks such as signal acquisition and signal tracking is described for both Loran C/D and Omega, using advanced radio navigation sensor design approaches as a basis. The more common application of computers to the task of converting from hyperbolic radio coordinates to geographic coordinates of latitude and longitude, and from these to UTM northing and easting, is treated, and the problems entailed in correcting these geographic coordinates for variations in radio propagation are also addressed. Simplified techniques for application of hyperbolic radio navigation data to guidance functions are discussed. Finally, the implications of Loran C/D and Omega processing tasks toward establishment of efficient architecture for airborne computers, are discussed, and short tables of desired instructions listed in order of importance are presented. Author

**N72-21228#** TRW Systems Group, Redondo Beach, Calif. Guidance and Navigation Lab  
**COMPUTERS FOR SATELLITE BASED NAVIGATION AND GUIDANCE SYSTEMS**

T. L. Rodrick and T. I. Fine / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 229-245 refs (See N72-21211 12-08)

Avail NTIS

The considerations involved in selecting a computer for an airborne navigation satellite user are examined. The software is described which will be used by navigation satellite users and which determines the user's computer requirements. The navigation satellite systems which are treated, are ranging or range differencing systems in which the user is passive (does not transmit to the satellite). The software is described in modular fashion to illustrate how a variety of user needs can be satisfied by different combinations of the same modular components. A description of the Kalman filter design considerations for a combined navigation satellite/inertial system is included which shows how computer speed and memory requirements depend upon the filter state vector size. Author

**N72-21227#** International Business Machines Corp., Owego, N.Y. Electronics Systems Center.

**COMPUTERS FOR THE GUIDANCE AND CONTROL OF TACTICAL AIRCRAFT**

W. J. Bernhart / In AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 247-268 (See N72-21211 12-08)

Avail NTIS

The navigational and guidance function provided a typical tactical application by utilization of a digital computer mechanization is analyzed. A brief description is given of the methods utilized to accomplish these functions and the sensors utilized in displaying pilot information and system configuration. The capabilities afforded the tactical vehicle by using digital devices for computation of navigational and guidance algorithms are summarized. Author

**N72-22168#** Advisory Group for Aerospace Research and Development, Paris (France).

**IMAGE STORAGE AND TRANSMISSION SYSTEMS FOR THE DISSEMINATION OF INFORMATION**

Feb. 1972 44 p refs Conf. Proc. Presented at Joint Meeting, Oslo, 9 Sep 1971

(AGARD-CP-92) Avail NTIS

Advanced systems of data processing are presented which involve the storage, retrieval, transmission, and reproduction of alphanumeric and pictorial data. Emphasis is placed on techniques of image conversion and display processes utilizing microfilms. For individual titles, see N72-22169 through N72-22173.

**N72-22169#** Massachusetts Inst of Tech., Cambridge Electronic Systems Lab

**AN EXPERIMENTAL TEXT-ACCESS SYSTEM**

Donald R. Knudson / In AGARD Image Storage and Transmission Systems for the Dissemination of Inform Feb. 1972 9 p refs Sponsored in part by NSF (See N72-22168 13-08)

Avail NTIS

A system is described which was designed to provide remote access to 90,000 pages of microfilm storage. It is part of a computer-oriented model library for conducting user experiments with two types of library retrieval: one provides access to the computer-stored catalog data for a group of selected documents and the second provides access to the microfilmed text of those documents. The text-access system automatically retrieves, scans, and transmits requested pages to remote display terminals utilizing a wideband transmission network. The current system employs two types of image-storage devices: a direct-view storage tube and a photographic camera. The microfilm images are scanned by a flying-spot scanner, and the scan-line density and sweep rates are varied to accommodate the limitations imposed by the different display terminals. A single coaxial cable path links the terminals to each other and to the central scanning station. Video signals are preceded by encoded digital messages containing a terminal address and commands for controlling terminal functions. A combined catalog/text terminal was developed which displays either the digitally-encoded catalog data or the text video signal on the same cathode-ray tube. The text display electronics were added to a commercially available computer terminal utilizing a storage-tube display to provide access to both catalog and text from a single terminal. Author

**N72-22170#** Internationals Dokumentationsgesellschaft fuer Chemie m b H., Frankfurt am Main (West Germany)

**COMPUTER AIDED INPUT OF GRAPHIC INFORMATION BY KEYBOARDING UNDER VISUAL CONTROL OF DISPLAY AS APPLIED TO CHEMICAL STRUCTURES**

Hans-Stefan Neubert / In AGARD Image Storage and Transmission Systems for the Dissemination of Inform Feb. 1972 6 p (See N72-22168 13-08)

Avail NTIS

A method is described, using computer supported keyboards with graphic displays, for processing and storing structural formulae of chemical compounds. By keyboarding the formula the graphic information is stored and the figure appears on the

screen where it can be verified visually and if necessary the input can be corrected. The proposed computer configuration allows the simultaneous input from 16 terminals. Author

**N72-22171#** National Physical Lab., Teddington (England). Information Systems Branch  
**PACKET-SWITCHING NETWORK**  
 D. L. A. Barber *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 12 p refs (See N72-22168 13-08)  
 Avail: NTIS

High speed store-and-forward packet-switching techniques are proposed as an alternative to the use of the public telephone network by remote access computing systems. The type of traffic generated when computer systems react with human beings and with each other is examined, and it is shown why the use of the telephone network has drawbacks. Packet-switching is demonstrated to be more appropriate for handling such traffic, and some existing and projected packet-switching schemes are described. The effect these schemes may have on the development of future computing systems is considered, both in respect of computer and terminal development. Author

**N72-22172#** Philco-Ford Corp., Willow Grove, Pa.  
**PHOTOTRANSMISSION AND VIDEO STORAGE**  
 Richard Schaphorst *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 12 p refs (See N72-22168 13-08)  
 Avail: NTIS

Four advanced digital visual communication systems for transmitting animated television, single frame television, and facsimile are described in detail. The utilization of a video disc recorder for efficient storage of television images is discussed in application to the single frame TV system. The Digital System designed for transmission over wideband circuits at 40 million bits/second provides high quality, fully animated color television service. The frame-to-frame Delta coding system operates at 16 million bits/second for digital transmission over conventional 5 MHz video circuits. The Vidicoder System stores TV pictures on a video disc recorder and provides for the digital transmission of a TV frame from one storage device to another up to 1 million bits/second. The Fastfax is a facsimile equipment which digitally transmits black/white and gray scale photographs over any communication channel up to 50 million bits/second. The four systems employ different picture coding and data compression techniques. DIGITEL employs two-bit Differential PCM; the Frame-to-Frame Delta System transmits brightness changes relative to a stored reference picture; the VIDICODER utilizes run length coding and bit plane coding; and the FASTFAX equipment employs run length coding and zero order interpolation processing. The relative performance and compression factors of these coding techniques are analyzed. Author

**N72-22173#** British Overseas Airways Corp., London (England).  
**PLANNING AND DEVELOPMENT OF COMPUTER OUTPUT ON MICROFILM FOR A COMMERCIAL APPLICATION**  
 B. S. Harris *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 8 p (See N72-22168 13-08)  
 Avail: NTIS

The computer/communications structure in a well-dispersed international organization are outlined, and a specific examination is made of the computer output to microfilm technique. The equipment used is described, principles of operation examined, and current and future applications discussed. Author

**N73-24201#** Advisory Group for Aerospace Research and Development, Paris (France).  
**GOVERNMENTAL ASSISTANCE FOR TECHNICAL INFORMATION IN INDUSTRY AND SIMPLE MECHANIZATION FOR SMALL INFORMATION CENTRES**

Mar. 1973 99 p refs. In ENGLISH partly in FRENCH. Presented at the 25th Meeting of the AGARD Tech. Inform. Panel, Ankara, 23-24 Oct. 1972  
 (AGARD-CP-117) Avail: NTIS HC \$7.00

The initiation and growth of small data centers and the problems of arranging them are summarized. Various forms and levels of information transfer to industry, from analysis and dissemination of summary reviews through visits to industry by technical information liaison personnel, to larger-scale nation wide dissemination to all interested firms, are discussed. For individual trials, see N73-24202 through N73-24212.

**N73-24202** Advisory Group for Aerospace Research and Development, Paris (France).  
**INTRODUCTORY PAPERS: THE PRESENT STATE OF INFORMATION ACTIVITIES IN TURKEY AND FUTURE TRENDS**

Kismet Burian (Scientific and Technical Research Council of Turkey) *In* its Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1973 4 p (For availability see N73-24201 15-08)

The state of the art of Turkey's information activities, as related to facilities and organizations of existing systems, are reported. Data are also given on TURDOK's role in designing a national information transfer system or network of systems to promote more effective and efficient execution of the national system. E.H.W.

**N73-24203** SACLAN ASW Research Center, La Spezia (Italy).  
**ESTABLISHING SMALL INFORMATION CENTRES IN INDUSTRY**

John P. Bethell *In* AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1973 7 p refs (For availability see N73-24201 15-08)

The function of a small information center in mediating between its community and the wider information network is explained, using the analogy of small medical centers. The differences between the information requirements of industry and those of science are emphasized and the desirability of clearly evaluating an industry's need for information before establishing an information center is indicated. Some of the specific duties of an industrial information center are described and it is stressed that these can now be most efficiently performed by requiring that the senior staff of the center have a broad education in information and its applications. It is recommended that the attitude of the center's staff and its organizational and physical location should be such as to maximize the center's orientation towards its users. Management is warned that some time must elapse before an information center becomes fully effective. Author

**N73-24204** Royal Aircraft Establishment, Farnborough (England).  
**LIBRARY AND INFORMATION SERVICES AT THE ROYAL AIRCRAFT ESTABLISHMENT. SOME PROBLEMS AND THEIR PRESENT SOLUTIONS**

R. C. Wright *In* AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1973 17 p (For availability see N73-24201 15-08)

Methods used to provide library and information services (more particularly information from books and journals) in a large research establishment (the services themselves being described in the Appendix) are outlined. Problems encountered in such an endeavor and present solutions to some of them are discussed. Author

**N73-24206** Ministry of Education and Sciences, Documentation Department, The Hague (Netherlands).  
**TRAINING OF PERSONNEL TO MAN THE VARIOUS PARTS OF AN INFORMATION CENTRE AND TO OPERATE VARIOUS KINDS OF SERVICE**

W. F. DeRegt *In* AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1972 4 p (For availability see N73-24201 15-08)

The problems and primary aims of training personnel or staff for an information center are outlined. Educational objectives



are formulated by which the sum total of attitudes, knowledge, and skills acquired by such personnel are defined. These objectives are also used to develop a suitable curriculum. Author

**N73-24206** Rome Air Development Center, Griffiss AFB, NY. **MICROFORMS: PRESENT ECONOMICS AND FUTURE USE** Fred S. Dyer. In AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres. Mar 1973. 6 p. refs. (For availability see N73-24201 15-08)

Basic microforms and their integration with machine processing to achieve highly versatile information systems are analyzed. Costs and future use of the integrated system are also discussed. Author

**N73-24207** Zentralstelle fuer Maschinelle Dokumentation (ZMD), Frankfurt (West Germany)

**PROBLEMS OF DATA RECORDING AND DATA INTERCHANGE**

Ruediger Bernhardt. In AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres. Mar 1973. 6 p. refs. (For availability see N73-24201 15-08)

Different data recording machines and their fonts of characters are outlined. Necessities and possibilities of structuring data are pointed out. Methods of checking and cleaning incorrect data are also mentioned. One of the possibilities of reducing the costs of data processing is the utilization of data interchange. Requirements concerning hardware and software for using interchange formats are explained. Author

**N73-24208** Advisory Group for Aerospace Research and Development, Paris (France)

**INPUT SYSTEMS AND RESEARCH FOR SMALL DOCUMENTARY CENTERS (SYSTEMES D'ENTREES ET DE RECHERCHES POUR DES CENTRES DOCUMENTAIRES DE FAIBLE OU MOYENNE IMPORTANCE)**

J. Klopp (CEDOCAR, Paris). In AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres. Mar 1973. 24 p. refs. In FRENCH (For availability see N73-24201 15-08)

Operating principles and types of data research centers are discussed. Data cover input systems, research format, data storage, automatic and mechanical research, and system classification.

Transl. by E.H.W.

**N73-24209** Defence Scientific Information Service, Ottawa (Ontario)

**PRESENTING A DEVELOPMENT PLAN FOR APPROVAL**

A. C. Jones. In AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres. Mar 1973. 5 p. refs. (For availability see N73-24201 15-08)

The impact of various ways of presenting proposals for creating and developing a new information facility on higher management are reviewed. Some of the difficulties of establishing and presenting user needs are explored, and an analogy is offered on surveying of commodity marketing and salesmanship. Careful tailoring was made to the proposal to suit the management functions and facilitate evaluation. Suggestions are made on objective facility development and proposal merits. Author

**N73-24210** Defence Research Information Centre, Orpington (England)

**TAILORED ABSTRACTS AND TECHNICAL DIGESTS: A SERVICE FOR INDUSTRY**

S. C. Schuler. In AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres. Mar 1973. 9 p. refs. (For availability see N73-24201 15-08)

Three information services are described, each aiming to give a degree of selectivity in order to reduce the total amount of material a user must scan in order to obtain the information of use to him. The services are (a) the IEE Tailored Abstracts (TABs) which provide sections of the comprehensive IEE Abstracts journals as separate bulletins, (b) R and D Report Announcements issued by the UK DTI-TRC to give selective subject coverage in four separate bulletins derived from the comprehensive R and D Abstracts journal, and (c) the DTI Techlink service which

provides one-page leaflets describing new materials, processes, techniques, etc., to individuals who have expressed an interest in the subject covered. The production and distribution of Techlinks are described in detail as the system can be used for the dissemination of various types of information. Author

**N73-24211** National Research Council of Canada, Ottawa (Ontario)

**INFORMATION EXTENSION SERVICES FOR INDUSTRY**

Gerard Kirouac. In AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres. Mar 1973. 4 p. (For availability see N73-24201 15-08)

A brief description is given of the experience of the Technical Information Service of the NRCC. Data emphasize the vital part of the liaison engineer in transferring technological information to small and medium scale industry through three sections of this service: the equity and answer division, the industrial engineering group and the technological development program. Improvements for the benefit of countries interested in this approach are suggested. Author

**N73-24212\*** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**THE DEVELOPMENT AND USE OF A MODERN DATA BANK**

Dudley G. McConnell. In AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres. Mar 1973. 8 p. (For availability see N73-24201 15-08)

CSSL 09B

The modern data bank emphasizes immediate access by a user community which may be large in number, widespread, and having varied needs. Electronic computers have been found very useful in the processing of stored information. The key to the design of a data bank is the optimum mix of human intellectual effort and mechanized processing. The elements of the NASA data bank are presented as one approach to the many trade-off decisions involved in the development of a data bank and integrated information system. Author

**N74-16925\*** Advisory Group for Aerospace Research and Development, Paris (France)

**NEW DEVELOPMENTS IN STORAGE, RETRIEVAL AND DISSEMINATION OF AEROSPACE INFORMATION**

Dec 1973. 107 p. refs. Presented at 26th Meeting of the AGARD Tech. Inform. Panel, London, 2-3 Oct 1973. (AGARD CP 136). Avail. NTIS HC \$8.50

The state of the art in computerized processing of aerospace information is examined, emphasizing mechanization developments with both large and minicomputers and in reprographics. For individual titles see N74-16926 through N74-16939.

**N74-16926** Kingston-Upon-Hull City Libraries, Hull (England)

**A COMPUTER PRODUCED KEYWORD INDEXING SYSTEM FOR TECHNICAL REPORTS IN THE LIBRARY OF THE AIRCRAFT RESEARCH ASSOCIATION LIMITED**

Christopher Barnett. In AGARD New Develop. in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973. 7 p. refs. (For availability see N74-16925 08-08)

A computer produced cataloguing and subject indexing system for report material acquired by the ARA library is described. Keyword listings with indexes under authors and originators, references are used to produce a monthly accession list and monthly and annual cumulating catalogues. The keywords are supplied manually using a specially constructed thesaurus. Author

**N74-16927** Defence Scientific Information Service, Ottawa (Ontario). Processing and Publishing Div.

**A MINI-COMPUTER BASED INFORMATION SYSTEM**

R. A. McIvor. In AGARD New Develop. in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973. 7 p. (For availability see N74-16925 08-08)

An automated information system is described based on two minicomputers, one of which is used for data input and the other for maintaining the master files and producing catalogue

cards, COM cartridges, KWOC indexes, indexed document digests, and SDI notices. This production is more economical than an earlier system using a larger computer. Author

**N74-16928** European Space Research Organization, Paris (France)

**AEROSPACE INFORMATION SERVICES: PROGRESS WITH THE ESRO-ELDO COMPUTERIZED INFORMATION NETWORK**

N E C Isotta. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 15 p. refs. (For availability see N74 16925 08-08)

The space documentation service is a joint organization of ESRO and ELDO. Described is the present system in operation, the files available and proposed, and probable short term developments within the next year and the possible future. The present network is regarded as the forerunner of a completely distributed network with auxiliary and main nodes at strategic centers having a number of different minicomputer possibilities.

G G

**N74-16929** Office for Scientific and Technical Information, London (England)

**THE ROLE OF OSTI IN INFORMATION RESEARCH AND DEVELOPMENT**

John Gray. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 3 p. (For availability see N74 16925 08-08)

The contribution of OSTI to information research and development in the UK over 8 + 2 years of existence is assessed. It is divided into four main sections: mechanized information systems, information analysis centers, and general research and management research (including library automation). In each section an attempt is made to summarize the main purpose of stimulating and supporting research and the principles that guide support. A concluding section deals briefly with support of research at Aslib and with the reviews of research in selected fields that OSTI has recently launched. Author

**N74 16930** Association of Special Libraries and Information Bureaux, London (England)

**CURRENT ASLIB RESEARCH ON MECHANISM**

B C Vickery. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 2 p. refs. (For availability see N74 16925 08-08)

An overview is given of the range of mechanization studies being carried out to explore the possibility of producing aerospace science abstracts by computer. Apart from statistical computations, computerized simulation of clerical processing in libraries is studied. The use of machine readable records to generate an index for optical searching and data processing is emphasized.

G G

**N74 16931** Transoceans Ltd, London (England)

**EDUCATION AND TECHNICAL TRAINING FOR TECHNICAL INFORMATION**

Felix Liebesny. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 3 p. refs. (For availability see N74 16925 08-08)

The educational and training facilities in the United Kingdom for scientific and technical information workers and librarians are outlined with reference to the various levels of professional attainment. The need for the training of teachers in these disciplines is stressed and some mention is made of forecast studies in supply and demand of information workers in the United Kingdom and the OECD countries. Author

**N74-16932** Greater London Council, England

**MICROFILM AND REPROGRAPHIC SYSTEMS: A STATE OF THE ART REVIEW**

Thomas J Morgan. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 5 p. (For availability see N74 16925 08-08)

A review of the reprographic equipment and systems is presented that covers photocomposing systems, computer output microfilming, microform retrieval and display systems, photo copiers and offset litho duplicating. Author

**N74-16933** Advisory Group for Aerospace Research and Development, Paris (France)

**REMOTE TRANSMISSION AND AUTOMATED RETRIEVAL TECHNIQUES**

R Barrett (Hatfield Polytechnic, England). In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 7 p. (For availability see N74 16925 08-08)

Actual developments which have taken place in the field of automatic retrieval and remote display of full text information held in microform stores and prospects for future developments are discussed. A feasibility study of remote access systems considers: (1) information bank and storage medium, including the selector mechanism; (2) terminal equipment including technical and user acceptability aspects; (3) transmission system; and (4) overall system economics. Although the primary interest in this study is library automation, the techniques considered are equally applicable to other automatic retrieval and remote display fields. Author

**N74-16934** Naval Weapons Lab, Dahlgren, Va. Technical Information Div

**RETRIEVAL OF MICROFICHE: RANDOM ACCESS**

Cathryn C Lyon. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 7 p. (For availability see N74 16925 08-08)

Three sizes of microfiche retrieval systems are discussed: small, medium and large, that give random access to microfiche and film chips. There are other random systems but they are usually set up for retrieval of microfilm. This paper describes these systems and suggests indexing methods and index format for use with them. It is intended to stimulate thinking about applications that are adaptable to the readers' collections.

Author

**N74-16935** Defense Documentation Center, Alexandria, Va.

**A MICROFICHE SYSTEM FOR SMALL USERS**

Hubert E Sauter. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 11 p. refs. (For availability see N74 16925 08-08)

Microfiche are particularly well suited to the reproduction, dissemination, storage and retrieval of documents or records, particularly those of 20-98 pages. Since fiche are flat microforms they are easily retrieved and can be quickly duplicated for mailing or reference. One of the major advantages of the microfiche is a possible savings of 70 percent or more in acquisition costs when a document is available in both microfiche and paper form. Another advantage is the elimination of document storage problems, since low-cost copies of microfiche can be produced at any point on demand. In many situations the most significant advantage is the savings in time and costs for packaging, shipping, storing and retrieving documents. The equipment for small users for duplicating microfiche copies is quite inexpensive when compared to the cost of roll film machines. Microfiche readers and reader printers are also considerably less expensive. The economies achieved are primarily due to simple designs, containing few moving parts or motors. Author

**N74-16936** GEC Marconi Electronics Ltd, Chelmsford (England) Research Labs

**A COMPUTER-CONTROLLABLE ULTRAFICHE TERMINAL**

F Duerden. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 7 p. (For availability see N74 16925 08-08)

The Automated Microform Terminal is a hardware contribution to the problem of cost effectiveness in computer aided learning, but the resultant specification was found to meet a need in information retrieval wherever the retrieval is from a large (say 200,000 pages upwards) to many millions or potentially large base via a computer searched index structure where a fast response is required to a specific enquiry. The terminal exploits the high storage density, handleability and low copy cost of 149 mm x 105 mm laminated ultrafiche (x 150 magnification). It has adequate precision to select and display any one out of 6000 individually addressable A5 pages from one fiche in 3 to 17 seconds under digital control either from computer or

keyboard. The addition of a small magazine or cassette under development, with automatic fiche selection and capacity for 1/4 million pages, makes the system capacity virtually open ended. Author

elaboration, complexity or cost. In this sense a streamlining and avoidance of duplication, unnecessarily elaborate gadgets etc., may be advantageous. Author

**N74-16937** European Atomic Energy Community, Luxembourg

**ABSTRACTS ON MICROFICHE FOR ON-LINE RETRIEVAL**  
Carl O. Vermimb. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 13 p (For availability see N74-16925 08-08)

A short description of the characteristics of the European nuclear documentation service is given: sources of information, structure of the thesaurus, file organization, retrieval strategy, system performance, and user behavior. Three recent developments are described: (1) installation of a terminal for system/user dialog, direct access to part of the data base (200 000 documents) allows for query adjustment by evaluating the relevance of titles presented on the screen; the adjusted query formulation is applied to the total data base of 1.3 million documents; (2) installation of a microfiche reader-printer with a capacity of close to 300 000 abstracts, the abstracts are presented on a ground-glass screen within 4 seconds after keying in the corresponding reference numbers; and (3) introduction of a relevance feedback routine, relevance decisions gathered when adjusting the query formulation are fed back into the computer together with the adjusted query, the descriptors are weighted according to their occurrence in relevant and irrelevant documents, the documents are ranked according to the sum of weights of their descriptors, and printed out in order of decreasing probability. Author

**N74-16938** Mullard Research Labs., Salfords (England)  
**A RESEARCH WORKER'S VIEW ON THE FUTURE OF AUTOMATIC READING MACHINES**

J. A. Weaver. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 8 p refs (For availability see N74-16925 08-08)

A general account of the justification for the use of automatic reading machines in a commercial data processing environment is presented. A broad outline of the tasks of the component parts of a reading system is given, together with an indication of how modern reading machines are being made more cost effective than their predecessors. A section is included on the recognition of handprinted material. Future techniques which may increase the capability of reading machines whilst maintaining the current trend towards reducing size and cost are considered. Optical character recognition has been in existence for several years - at a price. It will become very widely used over the next few years as prices fall and data processing managers realize how to use the technique effectively. Author

**N74-16939** Hawker Siddeley Aviation, Ltd., Kingston upon Thames (England)

#### **ALL CHANGE FOR AERONAUTICS**

John E. Allen. In AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform. Dec 1973 5 p (For availability see N74-16925 08-08)

The continuing patterns of changes in design, methods, subjects, fashion and major frameworks of reference have not only increased the volume of aerospace information but its complexity. The information world has responded to this by evolving more and more sophisticated indexing languages, thesaurus classification and automated retrieval. However, there is no consensus of opinion of a best way to proceed and as time goes on and first and second generation automatic systems come into use it will be increasingly difficult to introduce later methods because of the large capital replacement cost involved in such major changes. Costs of complex information systems may become an unacceptable proportion of organisational activity. Moreover such complexity and the existence of automatic systems may make too large demands on staff time, leaving less for consideration of the library/user interface. Often, in aircraft design there are similar tendencies - advanced technology may give a somewhat better aircraft but often only at the expense of more cost, complexity, unreliability etc. Good aeroplanes result from good design which is a strict discipline in avoiding unnecessary

09 ELECTRONIC EQUIPMENT

**09 ELECTRONIC EQUIPMENT**

Includes electronic test equipment and maintainability, component parts, e.g., electron tubes, tunnel diodes, transistors, integrated circuitry, microminiaturization. For basic research see 10 Electronics. For related information see also 07 Communication, and 21 Navigation.

No abstracts in this subject category

## 10 ELECTRONICS

Includes circuit theory, and feedback and control theory  
For applications see 09 Electronic Equipment For related  
information see specific Physics categories

**N74-13906#** Advisory Group for Aerospace Research and Development, Paris (France)

**COMPUTER AIDED DESIGN FOR ELECTRONIC CIRCUITS**  
Oct 1973 456 p refs Presented at 25th Tech Meeting on  
the Avionics Panel of AGARD, Lyngby, Denmark, 21-25 May  
1973

(AGARD-CP-130) Avail NTIS HC \$25.00

Conference papers are presented under the following  
headings: (1) reliability, (2) modelling, (3) microwave, (4) analog,  
(5) digital, and (6) layout For individual titles, see N74-13907  
through N74-13938

**N74-13907** Technical Univ of Denmark, Lyngby Institute of  
Circuit Theory and Telecommunication

# THE TEACHING OF CACA IN DENMARK

Erik Lindberg In AGARD Computer Aided Design for Electron  
Circuits Oct 1973 9 p refs (For availability see N74-13906  
05-10)

Computer aided circuit analysis (CACA) is a central discipline  
in the area of computer aided design of electronic circuits (CADEC).  
Since 1969, 10 courses in CACA have been offered and attended  
by about 190 persons. Nevertheless it has turned out that  
apparently it is very difficult to introduce CACA in the industry.  
The implementation and use are considered, of a common  
accessible library containing a number of programs for general  
circuit analysis. Two programs, ANP3 and NAP2, for linear and  
nonlinear systems analysis, respectively, are reviewed in brief.

Author

**N74-13908** Computer Aided Design Centre, Cambridge  
(England)

# ECONOMICS OF CAD: A NEW APPROACH

A. I. Jewell and G. C. Freeman In AGARD Computer Aided  
Design for Electron Circuits Oct 1973 10 p refs (For availability  
see N74-13906 05-10)

The economics of CAD is dependent on the degree to which  
commonalities can be recognised over a wide application front  
and embodied into common interactive software and a flexible  
computer system. The CAD Centre has worked closely with  
industry over the whole engineering front in order to identify  
such commonalities, while at the same time keeping its development  
to industrial needs and operating in a commercial environment  
where the economics of CAD is always in the forefront. The  
Centre's function and facilities and its method of operation are  
described. The economic advantages to be gained from the use  
of a common system developed through experience gained by  
multi-organization, multi-discipline working are discussed.

Author

**N74-13909** Admiralty Surface Weapons Establishment,  
Portsmouth (England)

# RELIABILITY RELATED TO COMPUTER AIDED CIRCUIT DESIGN: A USER'S VIEW

N. A. Walter and A. A. Kaposi In AGARD Computer Aided  
Design for Electron Circuits Oct 1973 10 p (For availability  
see N74-13906 05-10)

The problems of using computer aided circuit design in the  
reliability field are discussed and some of the possible reasons  
for the low utilization of computer aided circuit design are given.  
A method of simulating system reliability using computer aided  
circuit design type programs, is discussed and details given of  
such a method.

Author

**N74-13910** Radio Corp of America, Moorestown, N.J.  
Government and Commercial Systems Div  
**RELIABILITY AND COMPUTER AIDED DESIGN**

James G. Smith In AGARD Computer Aided Design for Electron  
Circuits Oct 1973 11 p refs (For availability see N74-13906  
05-10)

Information is presented to show that an integrated system  
of design aids raises the level of design assurance and thereby  
improves reliability. Topics of discussion include: (1) reliability  
at the expense of design complexity, (2) pertinent attributes of  
the computer, (3) standard cell automation, (4) the standard  
cell library, (5) computer aided circuit design, (6) logic simulation  
and test generation, (7) computer aided printed circuit board  
design, and (8) backplane wiring design automation. D.L.G.

**N74-13911** Technical Univ of Denmark, Lyngby  
**COMPUTER AIDED DESIGN FOR MAXIMUM PRODUCTION  
YIELD OR MAXIMUM RELIABILITY**

P. W. Becker and F. Jensen (Storno A/S, Copenhagen, Denmark)  
In AGARD Computer Aided Design for Electron Circuits Oct  
1973 14 p refs (For availability see N74-13906 05-10)

The use of computer aided design is demonstrated as a  
means of optimizing electronic circuit or system production yield,  
or, ultimately, drift reliability. A mathematical model for the yield  
or drift reliability is introduced, and methods for numerical  
evaluation hereof are briefly reviewed. The unhappy task of  
assembling pertinent component data for the computations is  
also touched upon. Various optimization techniques suitable for  
the problem at hand are next commented upon, and finally the  
theory is put into use by optimizing the yield of two transistor  
circuits. The results and implications of the optimization are  
discussed.

Author

**N74-13912** Electronique Marcel Dassault, St. Cloud (France)  
**COMPUTER AIDED DESIGN CONCEPTS (LA CONCEPTION  
DE PROJET ASSISTEE PAR ORDINATEUR)**

J. P. Vedei In AGARD Computer Aided Design for Electron  
Circuits Oct 1973 9 p In FRENCH (For availability see  
N74-13906 05-10)

A communication is presented on the use of computer  
concepts to aid in determining the reliability and costs of  
developing materials. The availability of the material was also  
considered.

Trans: by E.H.W.

**N74-13913** Louvain Univ (Belgium)

# THE USE OF THE TRANSISTOR SIMULATION PROGRAM SITCAP FOR STATISTICAL MODELING OF BIPOLAR TRANSISTORS

H. Daman, R. Merten, and H. Grevens In AGARD Computer  
Aided Design for Electron Circuits Oct 1973 11 p refs (For  
availability see N74-13906 05-10)

The program SITCAP is a simulator of bipolar transistors  
for computer aided circuit analysis. The main features of the  
program are its simple input/output structure and the new emitter  
model which is included in it. The main aspects of the program  
are described and examples are given of the application of the  
program for studying the statistical properties of bipolar transistors.  
It is demonstrated that in most cases the Gummel number must  
be taken as statistical variable, because the most important model  
parameters are correlated with it.

Author

**N74-13914** Norges Tekniske Høgskole, Trondheim  
**TRANSISTOR EQUIVALENTS**

O. G. Kjaerstad In AGARD Computer Aided Design for Electron  
Circuits Oct 1973 12 p refs (For availability see N74-13906  
05-10)

A method is presented to find the linear equivalent circuits  
of operational amplifiers and bipolar transistors. The method is  
general, and the same method can be used to find the equivalent  
circuits of other components. The method is based upon using  
a CAD-program to minimize an error function by varying the  
component values of an equivalent circuit. The error function is  
derived from the difference between the computed response of  
the component, for example a transistor, and the known response.  
The known response can be the measured frequency response  
or derived from the manufacturer's data. The results of two  
projects are presented which include: (1) operational amplifier

equivalent below 5 MHz, and (2) bipolar transistor equivalent below 30 MHz. A project to find the equivalent circuit at higher frequencies is outlined. Author

**N74-13915** Advisory Group for Aerospace Research and Development, Paris (France)  
**AN OPTIMIZATION TECHNIQUE TO CALCULATE BIPOLAR TRANSISTOR PARAMETERS**

Ronald J. Covello (Ellsworth AFB, South Dakota). *In its* Computer Aided Design for Electron. Circuits. Oct. 1973. 12 p. refs. (For availability see N74-13906 05-10)

Presently, a severe problem exists in nonlinear network analysis. Succinctly stated, this problem is that the measurement of the nonlinear parameters of bipolar transistors is time-consuming, difficult, and costly. An iterative computer technique is described for calculating these parameters using readily measured data. The technique uses a two level optimization process. Initially it assumes an arbitrary set of values for the parameters. It then calculates transistor currents based on these parameters and measured voltages. The calculated and measured currents are then compared and appropriate adjustments are made in the parameters. This process is repeated till calculated and measured values of transistor currents agree. At this time, the parameters are considered known. Results are shown which demonstrate the validity and applicability of the technique. Also, several minor modifications are suggested to optimize the process for production use. Author

**N74-13916** Elektronikcentralen, Hoersholm (Denmark)  
**LINEAR TRANSISTOR MODELS IN HF NETWORK ANALYSIS. ADAPTION BETWEEN MEASUREMENTS AND ANALYSIS BY COMPUTER**

P. Stangerup. *In* AGARD Computer Aided Design for Electron. Circuits. Oct. 1973. 22 p. refs. (For availability see N74-13906 05-10)

It is demonstrated that the problem of including transistor data in linear analysis programs is easily overcome by means of a simple mathematical model. This model can without difficulty be made to cover at least one decade at frequencies up to 1 GHz. At the higher frequencies, the best representation of the transistor is the S-matrix. Therefore it is desirable to make greater use of analysis programs based entirely on the S-parameter representation. Author

**N74-13917** Advisory Group for Aerospace Research and Development, Paris (France)

**L'UNIT TRANSISTOR. MODEL OF BIPOLAR TRANSISTOR HAVING CONTINUOUS PARAMETERS AS THE GEOMETRIC DIMENSIONS (TRANSISTOR UNITE, MODELE DE TRANSISTOR BIPOLAIRE EN CONTINU AYANT COMME PARAMETRES LES DIMENSIONS GEOMETRIQUES DES TRANSISTORS)**

P. Laduc. *In its* Computer Aided Design for Electron. Circuits. Oct. 1973. 14 p. refs. *In* FRENCH (For availability see N74-13906 05-10)

The addition of high level injection to IBIS transistor model and the effect of such an addition on continuous transistor functions are investigated. The revised model is applied to the determination of parameters for two transistors. A comparison was made of the measured and calculated gain and function of the collector circuit. Transl. by E.H.W.

**N74-13918** Siemens AG, Munich (West Germany). Central Telecommunications Lab

**STATE OF ART AND FUTURE TRENDS OF COMPUTER-AIDED DESIGN OF MICROWAVE INTEGRATED CIRCUITS**

Hans-Norbert Toussaint and Reinmut Hoffmann. *In* AGARD Computer Aided Design for Electron. Circuits. Jan. 1973. 14 p. (For availability see N74-13906 05-10)

The future trend of MIC design will be to combine the previously separate CAD branches into one CAD system. The hardware and software complement of this system is described. The principal constituents of the software are a conversion program which permits the network to be calculated directly

from the circuit layout, and a data bank in which the measured properties of special MIC components (e.g. transmission line discontinuities, lumped elements) are stored. Author

**N74-13919** Bell-Northern Research Ltd., Ottawa (Ontario)  
**A COMPUTER PROGRAM FOR ANALYZING WAVEGUIDE STRUCTURES**

Chuang-Jy Wu and Wayne Johnson. *In* AGARD Computer Aided Design for Electron. Circuits. Oct. 1973. 11 p. refs. (For availability see N74-13906 05-10)

A waveguide structure analysis program was developed in FORTRAN for implementation on an IBM 360/67 computer using the CP/CMS time sharing system. From an input of mechanical dimensions, equivalent circuits of waveguide obstacles are generated by using previously published theoretical and/or experimental results. Assuming that no evanescent mode interaction occurs between obstacles, an ABCD matrix manipulation is used to determine the overall network electrical response. In addition, a classical waveguide filter design program, temperature and mechanical stability tests, and a tuning procedure have been provided to help solve day to day engineering problems. Good agreement was obtained between measured and calculated results for waveguide transformers, and both bandpass and bandstop filters. The program is essentially a piece of powerful design equipment with broadband capability and provides the designer with instant tabulated performance information for analysis. Proper use of the program can save a considerable amount of model shop work and experimental effort in designing various types of waveguide networks. Author

**N74-13920** Servizio Meteorologico Italiano, Milano  
**COMPUTER OPTIMISATION OF MICROWAVE INTEGRATED CIRCUITS DESIGN**

S. V. Judd. *In* AGARD Computer Aided Design for Electron. Circuits. Oct. 1973. 8 p. ref. (For availability see N74-13906 05-10)

The design and implementation of a numerical optimization procedure are described suitable for realizing practical designs of hybrid microwave integrated circuits. Considerable attention was given to achieving low running costs in terms of computation time, in order to make the methods described economically viable. Author

**N74-13921** Technische Hogeschool, Delft (Netherlands)  
**Microwave Lab**

**DAP (DISTRIBUTION ANALYSIS PROGRAM) A PROGRAM FOR THE ANALYSIS AND DESIGN OF MICROWAVE CIRCUITS**

Joseph L. Tauntz. *In* AGARD Computer Aided Design for Electron. Circuits. Oct. 1973. 23 p. refs. (For availability see N74-13906 05-10)

DAP is an easy to use computer program facilitating the analysis and design of microwave circuits employing lumped and distributed elements. At present it has been in general use for over two years in the Microwave Laboratory of the Delft University of Technology. DAP utilizes a modified chain matrix analysis scheme coupled to an extensive repertoire of microwave elements. Lumped and distributed elements such as resistors, capacitors, inductors, lossy transmission lines (both inline and stub), transformers, and arbitrarily specified ABCD matrices constitute the normal circuit elements. The program's versatility is enhanced by the ease with which new element models may be added by the user. The report includes an introduction to the mathematical basis of the program, with emphasis on its more unusual aspects, supplemented by a number of design examples. The creation of special purpose element types to facilitate phase shifter, transistor amplifier and parametric amplifier analysis are described. A comparison with other presently available programs is made, serving designers in several Canadian cities. Author

**N74-13922** Toulouse Univ. (France)  
**MICROWAVE CIRCUIT ANALYSIS BY DIGITAL COMPUTER**

C. Vidallon. *In* AGARD Computer Aided Design for Electron. Circuits. Oct. 1973. 10 p. refs. (For availability see N74-13906 05-10)

The program ACLINE was conceived for the treatment in the frequency domain of the most general form of linear active networks with lumped and distributed elements (stubs, lines, coupled lines, circulators, etc.). The components of the network may be described as black boxes, characterized by S, Y or Z parameters, and stored in a library with a code name. It is also possible to use subnetworks, that are, after treatment, considered as conventional black-boxes. Four types of controlled sources allow the optimum choice of active devices equivalent circuits. A great number of results may be obtained from ACLINE, including all parameters or functions currently used to characterize linear networks performances in the frequency domain. Sensitivity computation is made through two different methods. For a check over a great number of components a general method is used. A simple step-by-step optimization process may then be applied over a small number of sensitive parameters with a faster method (IAM). Sophisticated mathematical models of microwave active devices are also included in the program (avalanche diode for example). Author

**N74-13923** Laboratoire Central de Recherches Thomson-CSF, Orsay (France)

**SYNTHESIS OF PASSIVE FILTERS WITH INFINITE ATTENUATION POINTS REALIZED WITH WEAK NOISE COMPONENTS APPLIED TO HIGH DEGREE CAUER FILTERS (SYNTHESE DE FILTRES PASSIFS A POINTES D'ATTENUATION INFINIES REALISEES AVEC DES COMPOSANTS A FAIBLES PERTES APPLICATION AUX FILTRES DE CAUER DE DEGRE ELEVE)**

C. Gimenes. In AGARD Computer Aided Design for Electron. Circuits, Oct. 1973, 11 p. refs. In FRENCH (For availability see N74-13906 05-10)

Computer synthesis of filters as a function of attenuation frequency and transfer function was discussed. After determining these functions, the impedance, overvoltage, entering filter components, terminal resistance, and transmission loss were determined. Component values and filter schemes are included. The functional characteristics of the filter were compared to those of high performance Caueir filters. Transl. by E.H.W.

**N74-13924** Societa Italiana Telecomunicazioni, Siemens SpA, Milan (Italy)

**COMPUTER DESIGN OF EQUAL RIPPLE EQUALIZATION**

A. Maggi and N. Montefusco. In AGARD Computer Aided Design for Electron. Circuits, Oct. 1973, 8 p. refs. (For availability see N74-13906 05-10)

A digital computer program for automatic equalization of group delay frequency characteristics is presented. The program solves in the most general manner, the problem of equal ripple equalization, with a limited computation time and a reduced number of positions in computer memory. The paper describes the iterative approximation process on a Newton-Raphson basis. An exhaustive analysis of the optimization and convergence of the procedure is also included. Finally the actual computer program is illustrated and some practical results are given. Author

**N74-13925** Southampton Univ. (England)  
**COMPUTER AIDED ANALYSIS OF ELECTRONIC CIRCUITS ON A SMALL MACHINE**

K. G. Nichols. In AGARD Computer Aided Design for Electron. Circuits, Oct. 1973, 10 p. refs. (For availability see N74-13906 05-10)

The reasons are explained for commencing computer aided design activities on a small machine at Southampton University. The cost of running the machine for this purpose is estimated. Details of programs for small signal linear circuit ac analysis and non-linear circuit dc and transient analysis are given. Examples of costs using these programs are included. The problems associated with implementing analysis programs on small machines are briefly discussed. Author

**N74-13926** Philips Gloeilampenfabrieken, N.V., Eindhoven (Netherlands) Research Labs

**STRUCTURE AND APPLICATION OF COMPUTER PROGRAM ICAN: INTEGRATED CIRCUIT AC ANALYSIS**

E. M. VanderOuderaa. In AGARD Computer Aided Design for Electron. Circuits, Oct. 1973, 15 p. refs. (For availability see N74-13906 05-10)

The computer program ICAN (Integrated Circuit Analysis) is capable of calculating ac properties (small signal) of bipolar integrated circuits. As input it needs technological data of the IC process: geometrical data (from the layout) and nodal connections. Details are given of the models used. To get an indication of the accuracy of ICAN it is applied to a current mode logic gate in the frequency range 100-500 MHz. The result is a reasonable agreement with measurements. To improve this agreement use was made of a more accurate two dimensional transistor model. Author

**N74-13927** Societe d'Etudes des Systemes d'Automation, Paris (France)

**IMAG 2: ELECTRONIC CIRCUIT SIMULATIONS**

Jean Arnould, J. P. Sicot, and Claude Lefaou (INPG). In AGARD Computer Aided Design for Electron. Circuits, Oct. 1973, 7 p. refs. (For availability see N74-13906 05-10)

IMAG 2 is a simulation program of linear or non-linear electronic circuits. It allows the computation of the circuit's response under various conditions: i.e. dc, ac, and transient analysis. It also gives the sensitivity of one or several output variables according to one or several circuit components. The program's use is simple and inexpensive because of the description's language and powerful calculation methods. Author

**N74-13928** Rockwell International Corp., Anaheim, Calif.  
**COMPUTER AIDED DESIGN ANALYSIS OF MODERN LARGE SCALE CIRCUITS AND SUBSYSTEMS**

W. Hochwald. In AGARD Computer Aided Design for Electron. Circuits, Oct. 1973, 41 p. refs. (For availability see N74-13906 05-10)

The SYSCAP (System of Circuit Analysis Program) SELECT (System Evaluation of Large Scale Electronic Circuits and Transforms) family of computer programs ranks among the more powerful computer aids available to the design, production, reliability, and logistics engineer. As such, SYSCAP SELECT encompasses proven technology in device modeling and mathematical structures, while stressing ease of usage and economy. Flexibility is provided to handle bipolar transistor electronics as well as MOS (Metal Oxide on Silicon) MSI/LSI (Medium and Large Scale Integrated) circuits on an individual basis, in hybrid configurations, in conjunction with functional system elements. The capabilities, user features, and options of SYSCAP SELECT are presented. A circuit example and a control loop subsystem design example are given. Theoretical background data are presented to substantiate the solution processes that are utilized. Application areas where SYSCAP SELECT has proven to be cost effective are described with reference to the development cycle of complex modern electronic and electro-mechanical equipment. Author

**N74-13929** Bell Northern Research Ltd., Ottawa (Ontario)  
**AN EVOLVING, OPERATIONAL COMPUTER AIDED DESIGN SYSTEM**

G. Scott, D. L. Williams, and L. C. Beaumont. In AGARD Computer Aided Design for Electron. Circuits, Oct. 1973, 12 p. refs. (For availability see N74-13906 05-10)

Computer graphics systems have not come into general use for computer aided design because of the high costs of both graphical hardware and graphical software. The equipment cost has decreased but programming costs remain high. A computer aided design system is described that uses a new high-level graphical language. The development of the language and of the translator and other programs in the system are also described. Some examples are given of applications using the language, which is at present running on a large time sharing computer serving designers in several Canadian cities. Author

**N74-13930** Brunel Univ., Uxbridge (England)  
**SPECIFICATION AND DESIGN LANGUAGES FOR LOGIC SYSTEMS**

Douglas Lawin. In AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs (For availability see N74-13906 05-10)

The techniques are examined of representing logical processes in such a way that the resultant structures may be used both for the analysis and synthesis of the final system. The requirements for logic design languages are defined and current techniques are surveyed. The interactive design languages under development for the CALD system are described.

D LG

**N74-13931\*** National Aeronautics and Space Administration  
 Marshall Space Flight Center, Huntsville, Ala  
**THE NASA COMPUTER AIDED DESIGN AND TEST SYSTEM**

J M Gould and K Juergensen. In AGARD Computer Aided Design for Electron Circuits Oct 1973 13 p refs (For availability see N74-13906 05-10)

A family of computer programs facilitating the design, layout, evaluation, and testing of digital electronic circuitry is described. CADAT (computer aided design and test system) is intended for use by NASA and its contractors and is aimed predominantly at providing cost effective microelectronic subsystems based on custom designed metal oxide semiconductor (MOS) large scale integrated circuits (LSICs). CADAT software can be easily adopted by installations with a wide variety of computer hardware configurations. Its structure permits ease of update to more powerful component programs and to newly emerging LSIC technologies. The components of the CADAT system are described stressing the interaction of programs rather than detail of coding or algorithms. The CADAT system provides computer aids to derive and document the design intent. Includes powerful automatic layout software, permits detailed geometry checks and performance simulation based on mask data, and furnishes test pattern sequences for hardware testing.

Author

**N74-13932** Societe Europeenne de Semiconducteurs et de Microelectronique, Paris (France)

**SIGMA: AN INTEGRATED SYSTEM OF COMPUTER AIDED COMPLEX CIRCUIT DESIGNS [SIGMA UN SYSTEME INTEGRE DE PROGRAMMES DE CONCEPTION ASSISTEE DES CIRCUITS COMPLEXES]**

J P Lusinchi. In AGARD Computer Aided Design for Electron Circuits Oct 1973 25 p refs. In FRENCH (For availability see N74-13906 05-10)

A detailed description is given of SIGMA a computer program designed to generate integrated and hybrid circuits. The program is divided into three parts: (1) IMAG 2T and PRIAM for analog simulation; (2) PSI for logical simulation and test sequence generation; and (3) GAMMA for diagram verification. Special circuits costs program applications are included.

Transl by E H W

**N74-13933** Motorola, Inc., Phoenix, Ariz. Semiconductor Products Div

**A COMPUTER AIDED DESIGN SYSTEM FOR LARGE SCALE INTEGRATED DIGITAL NETWORKS**

R G Hamer and C S Meyer. In AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs (For availability see N74-13906 05-10)

A CAD system presently being used in the design of LSI digital networks is described. Topics discussed cover logic system design and partitioning considerations, logic verification, circuit design, chip layout and mask generation. Computer programs are described which aid the designer in logic simulation, fault detection, non-linear circuit analysis in dc and transient modes, routing of cell interconnect, and mask generation.

Author

**N74-13934** REDAC Software Ltd., Tewkesbury (England)  
**COMPUTER AIDED DESIGN OF MULTILAYER PRINTED CIRCUIT BOARDS**

W E Hillier. In AGARD Computer Aided Design for Electron

Circuits Oct 1973 14 p refs (For availability see N74-13906 05-10)

The interactive computer layout of large multilayer printed circuit boards, including through via hole boards as well as bused via hole boards, is described. A full description of the software used is given together with details of the hardware and man machine interface. The system used is shown to be an extension of the internationally proven REDAC double sided PCB design package. The powerful software routines available for automatic routine and checking of the final layout are emphasized together with the ease with which the designer may interact with the program during its execution. It is shown that large layouts can be completed in a few weeks which would take a manual designer months to complete and would be very prone to manual designer error.

Author

**N74-13935** International Computers Ltd., Manchester (England)

**OPTIMISING AUTOMATIC TRACKING OF MULTILAYER BOARDS**

H G Adshead. In AGARD Computer Aided Design for Electron Circuits Oct 1973 16 p refs (For availability see N74-13906 05-10)

The paper commences with a brief but critical appreciation of some known automatic tracking techniques for multilayer printed circuit boards, viz. Maze-Running, Line-Search and Channel-Allocation. The purpose is to bring out their inherent similarity and to propound their specific superiority under different combinations of controlling criteria dictated by technological constraints. Consideration is given to the prohibitive core and time requirement for a real life environment involving an approximately 500 x 500 track matrix associated with the request for orthogonally connecting about 1,500 pin pairs on each board. The evolution of an effective algorithm and list-structure capable of successfully handling this problem is discussed in detail. Several side issues of major significance are introduced. The efficient pre-sorting of the order in which wires are submitted to the main algorithm has been found to make a significant contribution to the efficiency of the entire system. Profile analysis is developed as a technique for comparing the relative merits of various topological placements of the logic network. The importance of the basic board layout and its relation to the algorithm employed is stressed.

Author

**N74-13936** University of Southern Calif., Marina del Rey  
**A PARALLEL PRINTED CIRCUIT BOARD DESIGN SYSTEM**

Donald R Oestreicher. In AGARD Computer Aided Design for Electron Circuits Oct 1973 12 p refs (For availability see N74-13906 05-10)  
 (Contract F30602-70-C-0300)

A unique approach is described for the automatic design of printed circuit boards in which all functions can be accomplished in parallel. Instead of producing the layout wire by wire as is currently the rule, the layout is produced by traversing the board in a raster scan fashion, routing all relevant wires in parallel. This allows all design functions to be accomplished simultaneously. The fact that the layout functions are done concurrently provides for greater feedback among the different functions and therefore greater efficiency, as more relevant information is available to each function. The algorithm also makes great use of the commutivities introduced by integrated circuits. This is done by unbinding the circuit into a structure which describes all possible pin assignments, as defined by the relevant commutivities. This structure then maintains this information as the layout algorithm makes decisions to bind particular pins to particular logical signals. The structure not only remembers past decisions but it also makes all derivative bindings required by the layout algorithm's decisions necessary to maintain the equivalence between the input circuit description and the actual implemented circuit.

Author

**N74-13937** International Computers Ltd., Manchester (England)  
 Microsystems Div

**COMPUTER AIDED PLACEMENT AND ROUTING OF HIGH**



**DENSITY CHIP INTERCONNECTION SYSTEMS**

M. H. Cocker, R. W. McGuffin, R. Naylor, and H. Vosper. In AGARD Computer Aided Design for Electron Circuits. Oct 1973. 26 p. refs. (For availability see N74-13906 05-10)

A novel approach to the problem of placement and interconnection of components is presented. Conventional constraints, such as substrate or circuit board dimensions, are not considered at the outset; they are either absent or are suppressed until the stage is reached at which they are directly applicable. The chosen approach was adopted to facilitate the placement and tracking of integrated circuit chips on a microwired array. This form of construction, orthogonal tracks on either side of a dielectric layer connected by etched through-holes, has the advantage that the holes may be made within the width of a track. The algorithms presented are technology-independent and may be applied to any interconnection system which incorporates this feature. Initially, the logic is placed on a continuous plane. From this state, it is gradually transmuted through various cellular structures defined, initially by the components, and finally by a combination of the components and their associated tracks. The culmination is an arrangement which, at all stages, is determined by the logic and not the technology. Author

N74-13938 International Business Machines Corp., Owego, NY

**ERGONOMIC CONSIDERATIONS OF INFORMATION DISPLAY AND CONTROL FOR DESIGN AUTOMATION SYSTEMS**

William M. Gaddes. In AGARD Computer Aided Design for Electron Circuits. Oct 1973. 13 p. refs. (For availability see N74-13906 05-10)

A method is described for ensuring that appropriate considerations be given to the requirements of the intended users during system development. Trends in design automation systems are discussed, particularly with respect to the increased functional integration and interaction of the users with the system, as well as among multiple users. A method is described, based on user-oriented flow diagrams, which is intended to define the user requirements. A description is provided by which these diagrams are used to establish user requirements and to establish a communication link between the users and the system architects. Difficulties that may be expected with regard to user interfaces are listed, and the value of the method for establishing ergonomic design and evaluation criteria, procedural aids and methods, and educational materials is discussed. Author

## 11 FACILITIES, RESEARCH AND SUPPORT

Includes airports, lunar and planetary bases including associated vehicles, ground support systems, related logistics, simulators, test facilities (e.g., rocket engine test stands, shock tubes, and wind tunnels), test ranges, and tracking stations.

**N71-16060#** Advisory Group for Aerospace Research and Development, Paris (France)

### SIMULATION AGARD CONFERENCE PROCEEDINGS

Jan 1971 188 p refs AGARD Flight Mech Panel Specialists Symp held at Moffett Field, Calif 10-13 Mar 1970 (AGARD CP 79 70) Avail NTIS

#### CONTENTS

1 SIMULATION: AN INTRODUCTION AND SURVEY  
G F Bruening (DFVLR Oberpfaffenhafen, W Ger) 18 p refs (See N71-16061 06-11)

2 OBJECTIVES OF SIMULATION A G Barnes (British Aircraft Corp, Preston, Engl) 8 p (See N71-16062 06-11)

3 FLIGHT SIMULATOR MATHEMATICAL MODELS IN AIRCRAFT DESIGN A H Lee (Boeing Co., Seattle, Wash) 23 p refs (See N71-16063 06-11)

4 MOTION VISUAL AND AURAL CUES IN PILOTED FLIGHT SIMULATION K J Staples (RAE Bedford, Engl) 25 p refs (See N71-16064 06-11) 06-11)

5 COCKPIT ENVIRONMENT J Pinet (Soc Natl Ind Aerospatiale) 13 p refs (See N71-16065 06-11)

6 SOME FACTORS INFLUENCING THE CHOICE OF A SIMULATOR D M McGregor (NRC of Can, Ottawa, Ontario) 33 p refs (See N71-16066 06-11)

7 THE SELECTION OF TASK AND SUBJECTS OF FLIGHT SIMULATION EXPERIMENTS W O Breuhaus and R P Harper, Jr (Cornell Aeron Lab, Inc.) 17 p (See N71-16067 06-11)

8 ENGINEERING ANALYSIS M Monfort (Centre d'Essais en Vol, Istres, France) 22 p refs (See N71-16068 06-11)

9 PILOT ASSESSMENT ASPECTS OF SIMULATION G E Cooper and F J Drinkwater, III (NASA Ames Res Center) 12 p refs (See N71-16069 06-11)

**N71-16061#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberrhein (West Germany). Inst fuer Dynamik der Flugsysteme

### SIMULATION: AN INTRODUCTION AND SURVEY

Gerhard F Bruening / in AGARD Simulation Jan 1971 18 p refs (See N71-16060 06-11)  
Avail NTIS

A review is given on the state of the art of simulation. Linearized control theoretical aspects of simulation are discussed and examples of fixed base, moving base, and in-flight simulators are depicted with emphasis on the V-STOL problem. Ground simulators for environmental factors are analyzed with respect to motion, visual, and psychological parameters and methods for their simulation. The use of pilot opinion rating for evaluating simulation results is advocated. Differences between simulation on the ground and in the air are also outlined. G G

**N71-16062#** British Aircraft Corp, Preston (England)

### OBJECTIVES OF SIMULATION

A G Barnes / in AGARD Simulation Jan 1971 8 p (See N71-16060 06-11)  
Avail NTIS

Simulations are used to: (1) derive statements about properties of a system which may be read across to real situations; (2)

provide a framework for the interpretation of experiments; (3) improve a model; and (4) suggest further experiments. Flight simulation experiments provide accelerated development of aircrafts at reduced costs by defining what is required in order to transfer results readily with increased confidence to the real situation and thus cut down on trial and error aspects. G G

**N71-16063#** Boeing Co., Seattle, Wash

### LIGHT SIMULATOR MATHEMATICAL MODELS IN AIRCRAFT DESIGN

Alan H Lee / in AGARD Simulation Jan 1971 23 p refs (See N71-16060 06-11)  
Avail NTIS

Mathematical models are discussed from the viewpoint of a flight simulation user. Aerodynamic, flight control system, and atmospheric environment models are stressed. Some of their considerations are discussed relative to aircraft design phases. A quasi-elastic format for representing the aerodynamic characteristics of a large, flexible aircraft is described. It is shown that storing aerodynamic data in digital computers as split functions has advantages. Such items as controller feel, hysteresis, and actuator characteristics should be included in the flight control system mathematical model. Turbulence and wind shears are essential to any realistic simulation program. The von Karman power spectral density function is preferred for turbulence generations. Empirical wind shears are also useful. Author

**N71-16064#** Royal Aircraft Establishment, Bedford (England)

### MOTION, VISUAL AND AURAL CUES IN PILOTED FLIGHT SIMULATION

K J Staples / in AGARD Simulation Jan 1971 25 p refs (See N71-16060 06-11)  
Avail NTIS

The main characteristics of motion, visual and aural cues, are discussed for their integration into pilot flight simulation studies on variable stability aircraft. Areas of relevance and importance are defined for each of the cues and their interaction and substitution of one by another is considered. It is proposed that the principal attraction of simulation is speed and versatility in obtaining valid results for optimal man-machine integration. G G

**N71-16065#** Societe Nationale Industrielle Aerospatiale, Toulouse (France)

### COCKPIT ENVIRONMENT

Jean Pinet / in AGARD Simulation Jan 1971 13 p refs (See N71-16060 06-11)  
Avail NTIS

Various inputs of the simulation environment during Concorde cockpit development are considered. Computerized simulator trials started out with the variable stability Mirage 3B aircraft by considering external and internal visual displays, inertial perceptions and aural perception and verbal communications. Confrontation between simulation objectives and inputs and outputs of the crew members transfer functions with results from the various indices was used to define the environment simulation degree. G G

**N71-16066#** National Research Council of Canada, Ottawa (Ontario)

### SOME FACTORS INFLUENCING THE CHOICE OF A SIMULATOR

D M McGregor / in AGARD Simulation Jan 1971 33 p refs (See N71-16060 06-11)  
Avail NTIS

Some of the means by which the pilot derives motion information during flight and attempts to highlight some of the areas in which specific simulator characteristics are required to

obtain valid results are outlined. Discussions of several shortcomings of present hardware that must be overcome before specific tasks, such as low altitude, low speed maneuvering flight, can be simulated adequately and the difficulties of achieving a thorough understanding of the man-machine system are presented. Author

**N71-16067#** Cornell Aeronautical Lab, Inc. Buffalo, NY  
**THE SELECTION OF TASKS AND SUBJECTS OF FLIGHT SIMULATION EXPERIMENTS**

Waldemar O. Beuhaus and Robert P. Harper, Jr. In AGARD Simulation Jan 1971 17 p (See N71-16060 06-11)  
 Avail NTIS

The limitations of various simulators directly affect the simulation tasks which can be performed and, hence, affect the validity of the evaluation results obtained. The ability of simulator pilots to produce valid and repeatable evaluations which are applicable to the real world situation can be no better than the accuracy with which the simulator tasks represent the essential characteristics of the real world. Certain considerations in the selection of simulator tasks are discussed, and problems are set forth which should be considered in the design of simulation experiments. The selection and preparation of evaluation pilots are discussed in terms of the factors which appear to have substantial effects upon the program results. Experience in the real-world mission is one of several key elements which greatly enhances the evaluation results. Preparation of subjects considers the importance and nature of communication between the subject pilot and the analyst and participation of the subjects in the experimental design. Author

**N71-16058#** Centre d'Essais en Vol, Istres (France)

**ENGINEERING ANALYSIS**

M. Monfort. In AGARD Simulation Jan 1971 22 p refs  
 (See N71-16060 06-11)  
 Avail NTIS

The mixing of several simulation methods is advocated for engineering analyses on flight mechanics. Emphasis is placed on analysis of the pilot's behavior for integration in the man-machine system by application of statistical and response surface techniques to both pilot ratings and pilot comments in measuring the pilot's workload. G.G.

**N71-16069#** National Aeronautics and Space Administration  
 Ames Research Center, Moffett Field, Calif

**PILOT ASSESSMENT ASPECTS OF SIMULATION**

George E. Cooper and Fred C. Drinkwater, III. In AGARD Simulation Jan 1971 18 p refs (See N71-16060 05-11)  
 (NASA TM-X 66583) Avail NTIS CSCL05H

Pilot assessment aspects of flight simulation consider the use of pilot ratings in the evaluation of aircraft handling qualities. Critical questions raised by pilots are examined and discussed in order to develop solutions and improve understanding. It is important to involve the pilot as early as possible in developing a piloted simulation program by considering complaints arising from simulation experiences as well as questions arising related to the pilot's actual participation in the planning and conducting of experiments in the simulation facility and the analysis of results. Author

**N71-34253#** Advisory Group for Aerospace Research and Development, Paris (France)  
**INVENTORY OF ACOUSTIC FATIGUE TEST FACILITIES IN THE NATO COUNTRIES**

B. L. Clarkson (Southampton Univ.) Jul 1971 15 p refs  
 (AGARD-R-584-71, AGARD-Rept 584) Avail NTIS

The acoustic test facilities for NATO are listed as of 1969. The characteristics of the noise generators including frequency

range, sound levels, and typical spectrum provided are tabulated. The instrumentation and data analysis systems are also tabulated for each facility. F.O.S.

**N72-12162#** Advisory Group for Aerospace Research and Development, Paris (France)

**FACILITIES AND TECHNIQUES FOR AERODYNAMIC TESTING AT TRANSONIC SPEEDS AND HIGH REYNOLDS NUMBER**

R. C. Pankhurst. Oct 1971 11 p refs  
 (AGARD-AR-37-71) Avail NTIS

Scale effects on various flow phenomena and for various body shapes are discussed. Techniques are given for simulating the effects of higher Reynolds numbers. The requirements and types of experimental facilities which can achieve high Reynolds numbers at transonic speeds are considered. Author

**N73-18260#** Advisory Group for Aerospace Research and Development, Paris (France)

**AERODYNAMIC TEST SIMULATION: LESSONS FROM THE PAST AND FUTURE PROSPECTS**

Julius Lukasiewicz, ed. (Carleton Univ.) Dec 1972 89 p refs  
 Presented at AIAA 10th Aerospace Sci Meeting Panel Discussion, San Diego, Calif., 19 Jan 1972  
 (AGARD-R-603) Avail NTIS HC \$6.50

Developments in aerodynamic test facilities used by government, university, and industry are discussed. The following topics are reported: (1) assessment of past experience, (2) present status and future prospects of aerodynamic and air breathing propulsion testing in all speed regimes, (3) ground test and flight comparisons, (4) free flight test techniques, and (5) the development of aerodynamic testing. A review of the major West European wind tunnels and a discussion of aerodynamic test facilities in the United States are included in two appendices. Author

**N73-20269#** Advisory Group for Aerospace Research and Development, Paris (France). Large Wind Tunnels Working Group.  
**THE NEED FOR LARGE WIND TUNNELS IN EUROPE**

Dec 1972 96 p refs  
 (AGARD-AR-60) Avail NTIS HC \$7.00

The Report of the Large Wind-Tunnels Working Group of the AGARD Fluid Dynamics Panels, follows nine meetings between December 1971 and November 1972. Review of existing position and future prospects, the role of the wind-tunnel in research and development, existing European wind-tunnels present national plans for wind-tunnels, future needs, options for new large low-speed and transonic tunnels, a proposed time schedule for provision of new tunnels, and proposals for a collaborative work program to clarify existing problems in wind-tunnel design and operation. It is concluded that the first priority is for a new large pressurized transonic wind-tunnel in Europe, four possible options for realization of this need are given, and an Engineering Study is proposed, with a Work Statement, to assess and evaluate the engineering requirements of the options. The second priority, of importance almost equal to the first, is for a new large low-speed wind-tunnel. This should be of 18 m or 25 m width. The Group has not been able to agree between these figures. Provision of new European supersonic and hypersonic facilities should begin when the subsonic and transonic requirements have been met, long term technical needs for these are defined. Author

**N73-26239#** Advisory Group for Aerospace Research and Development, Paris (France)

**PROBLEMS IN WIND TUNNEL TESTING TECHNIQUES**

Apr 1973 165 p refs  
 (AGARD-R-601, AGARD-601) Avail NTIS HC \$10.25

The design and operation of large wind tunnels for low speed and transonic speed conditions are described. The subjects discussed include the following: (1) methods for correcting wall constraints in transonic wind tunnels, (2) interference effects of model support systems, (3) minimum required measuring times

to perform stationary measurements in transonic tunnels, (4) wind tunnel requirements for helicopters, and (5) acoustic considerations for noise experiments at model scale in subsonic wind tunnels. For individual titles, see N73-26240 through N73-26247.

**N73-26240** Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

**REVIEW OF SOME PROBLEMS RELATED TO THE DESIGN AND OPERATION OF LOW SPEED WIND TUNNELS FOR V/STOL TESTING**

Mario Carbonaro. In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 24 p. refs. (For availability see N73-26239 17-11)

A review is made of a number of operational problems associated with the wind tunnel testing of V/STOL aircraft including helicopters. The following subjects are discussed: (1) wall constraints, (2) use of ventilated walls, (3) testing for ground effect, and (4) flow disturbances in the tunnel circuit. Mathematical models are developed to clarify the theoretical aspects of wind tunnel operation. Author

**N73-26241** Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Aerodynamics Dept.

**SURVEY OF METHODS FOR CORRECTING WALL CONSTRAINTS IN TRANSONIC WIND TUNNELS**

Jean-Ch Vayssaire. In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 48 p. refs. (For availability see N73-26239 17-11)

The use of ventilated walls in transonic wind tunnels and the effect on wall interference corrections are discussed. Mathematical applications of the extreme cases of zero permeability and infinite permeability are examined. The solutions are compared and the characteristics of theoretical working sections are analyzed. Mathematical models are provided to support the theoretical considerations. Author

**N73-26242** Aircraft Research Association, Ltd., Bedford (England).

**INTERFERENCE EFFECTS OF MODEL SUPPORT SYSTEMS**

E. C. Carter. In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 10 p. refs. (For availability see N73-26239 17-11)

The forms of interference occurring in subsonic and transonic wind tunnels due to model support systems are discussed. Two types of model attachment, rear sting and vertical blade sting, are considered and the form and magnitude of interference terms are given for some particular examples. The buoyancy interference in the working section due to a typical sting joint and roll mechanism behind a model is considered and the effect on drag is evaluated for two typical bodies. Author

**N73-26243** Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam (Netherlands).

**MINIMUM REQUIRED MEASURING TIMES TO PERFORM INSTATIONARY MEASUREMENTS IN TRANSONIC WIND TUNNELS**

J. W. G. VanNunen, G. Coupy (ONERA, Chatillon-sous-Bagneux, France), and H. Foersching (DFVLR, Goettingen, West Germany). In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 2 p. refs. (For availability see N73-26239 17-11)

The minimum required run times for instationary measurements at transonic speeds during wind tunnel tests are analyzed. The subjects discussed are: (1) instationary pressure measurement techniques, (2) flutter tests, (3) buffet measurements, and (4) cross correlation techniques. It is concluded that present test methods require a minimum running time of ten seconds. It is suggested that new test techniques may reduce the time requirement. Author

**N73-26244** Royal Aircraft Establishment, Bedford (England).

**SOME CONSIDERATIONS OF TESTS UNDER DYNAMIC CONDITIONS IN LOW SPEED WIND TUNNELS**

D. N. Foster. In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 4 p. refs. (For availability see N73-26239 17-11)

The objectives of dynamic tests conducted in low speed wind tunnels are examined. For a number of specific problems for measurements under static conditions it is possible that special techniques and new equipment will be required. The two general areas of consideration are: (1) measurement of oscillatory derivatives and (2) measurement of transient motions caused by gusts and ground effect. It is concluded that the main requirements for data relevant to dynamic effects can be met under static conditions over a wide range of variables. Author

**N73-26245** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Aerodynamische Versuchsanstalt.

**USE OF MODEL ENGINES (V/S/CTOL)**

E. Melzer and R. Wulf. In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 17 p. refs. (For availability see N73-26239 17-11)

The special conditions required to conduct wind tunnel tests of jet aircraft engines are examined. The capabilities for simulation in atmospheric tunnels are discussed. The problems of testing in pressurized tunnels are analyzed. An estimation of the energy, the plants, and the test equipment required for engine simulation are listed. Author

**N73-26246** Westland Helicopters, Ltd., Yeovil (England).

**WIND TUNNEL REQUIREMENTS FOR HELICOPTERS**

I. A. Simons and H. Derschmidt (MBB, Munich). In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 10 p. refs. (For availability see N73-26239 17-11)

The sizes of model which are most suited to various aspects of wind tunnel tests of helicopters are defined. The scaling laws and associated constructional problems of small scale rotor systems are discussed. Tunnel sizes are suggested for various ranges of model size based on a consideration of interference effects. Author

**N73-26247** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

**ACOUSTIC CONSIDERATIONS FOR NOISE EXPERIMENTS AT MODEL SCALE IN SUBSONIC WIND TUNNELS**

T. A. Holbeche and J. Williams. In AGARD. Probl in Wind Tunnel Testing Tech. Apr. 1973. 30 p. refs. (For availability see N73-26239 17-11)

Acoustic consideration for noise experiments at model scale in subsonic wind tunnels are presented. Emphasis is placed on similarity to flight test conditions, noise measurement constraints on model and tunnel sizes, the parasitic effects of background noise, and the various factors contributing to the generation of noise. The specific contributions to tunnel noise from the tunnel drive fan, the tunnel circuit, the test section mainstream flow, and the particular test section boundary conditions are discussed. Author

**N74-16987\*** Advisory Group for Aerospace Research and Development, Paris (France).

**PROBLEMS OF WIND TUNNEL DESIGN AND TESTING**

Dec. 1973. 179 p. refs. Mostly in ENGLISH, partly in FRENCH.

(AGARD R 600). Avail. NTIS HC \$12.00

The design and operation of low speed and transonic wind tunnel are discussed. Emphasis is placed on possible future large wind tunnels for Europe. The subjects discussed are: (1) transonic Ludwig tube wind tunnel, (2) system for generation of quiet transonic flows for model testing at high Reynolds number, (3) the injector driven wind tunnel, and (4) facilities for aerodynamic testing at hypersonic speed. For individual titles, see N74-16988 through N74-16993.

**N74-16988** Royal Aircraft Establishment, Farnborough (England).

**SOME CONSIDERATIONS OF FUTURE LOW-SPEED TUNNELS FOR EUROPE**

A. Spence and B. M. Spee (Natl. Aero. and Astronaut. Res. Inst., Amsterdam). In AGARD. Probl in Wind Tunnel Design and Testing. Dec. 1973. 10 p. Prepared in cooperation with

Natl. Aero- and Astronaut Res. Inst., Amsterdam (For availability see N74-16987 08-11)

Two series of possible future low-speed windtunnels have been studied. The first series are high-Reynolds-number tunnels having a product of working section width in metres and maximum pressure in atmospheres kept constant at a value of 45, but including in addition a 60m atmospheric tunnel. The second series comprises atmospheric tunnels of widths ranging from 8m to 25m, and these are of more modest cost and generally lower capability than the first series. Very broad estimates of possible capital and running costs are given as an indication of the scale of expenditure which might be involved; no precise quotations have been obtained. Brief statements are made of the capabilities of the tunnels considered. Each series in turn appears to offer attractive possibilities for future provision of low speed tunnels in Europe. Author

**N74-16989** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany) Inst fuer Stromungsmechanik

**PROJECT STUDY OF A LARGE EUROPEAN TRANSONIC LUDWIG TUBE WINDTUNNEL**

H. Ludwig, H. Grauer-Carstensen, and W. Lorenz-Meyer. In AGARD Probl of Wind Tunnel Design and Testing Dec 1973 22 p. refs (For availability see N74-16987 08-11)

A study of a transonic Ludwig Tube wind tunnel is presented. For a reliable extrapolation of windtunnel measurements to full-scale flight conditions of modern aircraft, a realistic simulation of flight Reynolds numbers at transonic speeds becomes increasingly important. It is shown, how the need for a high Reynolds number experimental facility can be satisfied by a Ludwig Tube tunnel. The Ludwig Tube is characterized by its unsurpassed simplicity which guarantees a high degree of reliability. Design data, dimensions, and cost estimates for the described tube wind tunnel are presented. The basic facility characteristics are given. Author

**N74-16990** Royal Aircraft Establishment, Bedford (England) **THE DEVELOPMENT OF AN EFFICIENT AND ECONOMICAL SYSTEM FOR THE GENERATION OF QUIET TRANSONIC FLOWS SUITABLE FOR MODEL TESTING AT HIGH REYNOLDS NUMBER**

P. G. Pugh. In AGARD Probl of Wind Tunnel Design and Testing Dec 1973 17 p. refs (For availability see N74-16987 08-11)

Current work on the development of the ECT drive system is reviewed. It is shown that this is a particularly economical and effective means of providing a radical improvement in the Reynolds numbers at which transonic wind-tunnel tests can be performed. Experimental trials which confirmed the practicability of the essential features of this system are described, and the problems of optimizing the design of a particular wind-tunnel are discussed. Author

**N74-16991** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

**THE INJECTOR DRIVEN TUNNEL**

Pierre Carriere. In AGARD Probl of Wind Tunnel Design and Testing Dec 1973 56 p. refs (For availability see N74-16987 08-11)

The development and characteristics of an injector driven wind tunnel are described. The subjects discussed are: (1) methods for evaluating and optimizing the performance in steady continuous flow; (2) analysis of unsteady phenomena during the wind tunnel start; and (3) problems of intense noise generated by the jets. Indications on the orders of magnitude of basic technological data. Sketches of the active part of the induction driven tunnel and a graph of the thermodynamic cycle are presented. Author

**N74-16992** Institut Aerotechnique Le Saint-Cyr, Saint-Cyr-l'Ecole (France)

**HYDRAULIC COMPRESSOR WIND TUNNEL [SOUFFLERIE A COMPRESSEUR HYDRAULIQUE]**

Maurice Menard and Francis Chometon. In AGARD Probl of

Wind Tunnel Design and Testing Dec 1973 28 p. refs. In FRENCH (For availability see N74-16987 08-11)

A description is given of a motor system for transonic wind tunnels with large Reynolds numbers. The installation and its functions were also described. Theoretical studies were made of thermodynamic cycles based on the possible evolution of power absorbed by the installation. Data are also given on the economics of the wind tunnel project, technological solutions proposed, and proper reservoir construction. Transl by E.H.W.

**N74-16993** National Aerospace Lab., Amsterdam (Netherlands)

**FACILITIES FOR AERODYNAMIC TESTING AT HYPERSONIC SPEEDS**

F. Jaarsma and W. B. DeWolf. In AGARD Probl of Wind Tunnel Design and Testing Dec 1973 40 p. refs (For availability see N74-16987 08-11)

An assessment is made of the usefulness and potential of existing European hypersonic facilities, on the basis of the planned US space shuttle project and a hypothetical hypersonic transport aircraft. With respect to aerodynamic testing of space shuttle type of vehicles it is pointed out that a significant gap exists between  $M = 10$  and  $M = 15$ . At low-hypersonic Mach numbers the facilities in Europe will generally meet the minimum requirements for testing hypersonic transport models. European capabilities appear to be rather similar to those in the US hypersonic wind tunnels, though the US capabilities will be increased considerably in the near future. It is further concluded that European facilities fall short in their performance of what is required, in the field of propulsion (including supersonic combustion tests) and also of hardware testing. Author

## 12 FLUID MECHANICS

Includes boundary-layer flow, compressible flow, gas dynamics, hydrodynamics, and turbulence. For related information see also 01 Aerodynamics, and 33 Thermodynamics and Combustion

**N71-26073#** Advisory Group for Aerospace Research and Development, Paris (France)

### REPORT OF THE HIGH REYNOLDS NUMBER WIND TUNNEL STUDY GROUP OF THE FLUID DYNAMICS PANEL

Apr 1971 24 p refs

(AGARD-AR-35-71) Avail NTIS

The working group considered transonic wind tunnel performance and operating characteristics required to support evolution of military and civil aeronautical and aerospace systems during the coming decade. These considerations, along with a review of experience on model testing at transonic speeds, led to the conclusion that the NATO nations should acquire, as soon as possible, two types of new wind tunnels. One tunnel should duplicate transonic flight Reynolds numbers and have a run time on the order of one second. The second should have a 16 ft test section and should provide Reynolds numbers that are 3 or 4 times the maximum presently available, with a run time on the order of 10 seconds. It was also concluded that AGARD should support current research and development in design, operation and test techniques in transonic tunnels of the continuous, conventional blowdown and Ludwieg tube type and that AGARD should encourage expansion of these activities in the future. Author

**N72-15269#** Advisory Group for Aerospace Research and Development, Paris (France)

### TABLES OF INVISCID SUPERSONIC FLOW ABOUT CIRCULAR CONES AT INCIDENCE, GAMMA EQUALS 1.4, PART 3

D J Jones (Natl Aeron Estab, Ottawa Ontario) and W J Rainbird, ed (Carleton Univ) Dec 1971 172 p refs

(AGARDograph-137-PT-3, AGARD-AG-137-71-PT-3)

UDC-533 696.4 533 6 011 5 083) Avail NTIS

Tabulated results are presented for half cone angles of 45, 47.5, 50, 52.5, and 57 degrees with Mach numbers ranging from 3 to 20. Author

**N72-20273#** Advisory Group for Aerospace Research and Development, Paris (France)

### TURBULENT SHEAR FLOWS

Jan 1972 506 p refs Presented at the Fluid Dyn Panel Specialists Meeting, London, 13-15 Sep 1971

(AGARD-CP-93) Avail NTIS HC \$6.00 MF \$0.95

Turbulent shear flows such as boundary layers, jets, and wakes, were investigated for nonreacting gas flow. Factors considered were the basic structure of equilibrium shear flows and the influence of compressibility, pressure gradients, surface curvature, three-dimensional flows, noise density, and/or temperature gradients. For individual titles, see N72-20274 through N72-20307

**N72-20274#** Imperial Coll of Science and Technology, London (England) Dept of Aeronautics

### VARIATIONS ON A THEME OF PRANDTL

Peter Bradshaw /in AGARD Turbulent Shear Flows Jan 1972 10 p refs (See N72-20273 11-12)

Avail NTIS HC \$6.00 MF \$0.95

Varieties of complex turbulent flow which are important in engineering are recognized as perturbations of classical thin shear layers to which Prandtl's approximation applies. The types

distinguished are: (1) shear layers, (2) shear layers perturbed by small additional strain rates which produce appreciable changes in turbulence, and (3) shear layers perturbed by large additional strain rates. Examples are airfoil boundary layers merging into a wake, boundary layers on curved surfaces, and reattaching shear layers. The essential phenomena of these turbulent flows are discussed, and it is concluded that a program of turbulence measurement should enable calculation methods to be extended to a wide range of complex flows. A discussion of the general types of calculation methods suitable for complex flows is included. Author

**N72-20275#** Michigan Univ, Ann Arbor Dept of Aerospace Engineering

### STRUCTURE OF THE REYNOLDS STRESS NEAR THE WALL

W W Willmarth and S S Lu /in AGARD Turbulent Shear Flows Jan 1972 20 p refs (See N72-20273 11-12)

(Contract N00014-67 A-0181-0015)

Avail NTIS HC \$6.00 MF \$0.95

Experimental studies are reported on the flow field near the wall in a turbulent boundary layer using hot wire probes. Measurements of the product  $uv$  were made using conditional sampling and with the aid of a digital computer. The criterion used to determine when  $uv$  was to be sampled was when streamwise velocity at the edge of the sublayer had attained a certain value. It was found that 60% of the contribution to  $uv$  occurred when the sublayer velocity was lower than mean velocity. Measurements involving correlation of truncated  $u$  and  $v$  signals revealed that the largest portion of Reynolds stress and turbulent energy components occurs when  $u < 0$ ,  $v > 0$ , or during an intense bursting process, the remainder occur during recovery. Contributions to the production of turbulence and Reynolds stress at a point near the wall are of large magnitude, short duration, and intermittent. A rough measure of the intermittency factor for  $uv$  is 0.55. Author

**N72-20276#** Aix-Marseille Univ (France) Inst de Mecanique Statistique de la Turbulence

### SPECTRAL DISTRIBUTIONS OF THERMAL FLUCTUATIONS IN A TURBULENT BOUNDARY LAYER (REPARTITIONS SPECTRALES DES FLUCTUATIONS THERMIQUES DANS UNE COUCHE LIMITE TURBULENTE)

L Fulachier and R Dumas /in AGARD Turbulent Shear Flows Jan 1972 10 p refs In FRENCH, ENGLISH summary (See N72-20273 11-12)

Avail NTIS HC \$6.00 MF \$0.95

Temperature fluctuation spectra and spectral distributions of temperature velocity were measured in a turbulent boundary layer on a heated flat plate. The method of fluctuation diagramming was used for frequency-filtered signals in order to measure spectral correlation distribution. A comparison of thermal spectra and three velocity components is presented from the internal zone as far as the edge of the boundary layer. Balance equations are given for spectral distributions relative to temperature and the sum  $Q(n)$  for the spectra of the velocity components. Spectral distributions of production terms and molecular dissipation are also considered. Author

**N72-20277#** University of Southern Calif, Los Angeles Dept of Aerospace Engineering

### INTERMITTENT STRUCTURES IN TURBULENT BOUNDARY LAYERS

R F Blackwelder and R E Kaplan /in AGARD Turbulent Shear Flows Jan 1972 7 p refs (See N72-20273 11-12)

(Grants NSF GK 24578, NSF GK 27800)

Avail NTIS HC \$6.00 MF \$0.95

The intermittent structure in the outer region and the occurrence of intermittent bursts near the wall were investigated. The extent of these structures is characterized by the existence of streamwise momentum deficits. Correlations suggest a connection between bursting that occurs in the wall region and the intermittent bulges of turbulence that protrude from the

outer reaches of the turbulent boundary layer. A scheme is presented for the detection of turbulent bursts near the wall. Conditional averaging showed that during the burst there was a substantial streamwise momentum defect followed by an extremely rapid acceleration. The measurements suggest that perhaps a local instability is the source of the break-up of the wall flow. Author

**N72-20278#** Technische Univ., Berlin (West Germany) Inst. fuer Ueberschall Technik.

**AN INTEGRAL METHOD FOR APPROXIMATE CALCULATION OF COMPRESSIBLE TURBULENT BOUNDARY LAYERS WITH STREAMWISE PRESSURE GRADIENT**

H.-J. Kuester. In AGARD Turbulent Shear Flows Jan. 1972 20 p refs (See N72-20273 11-12)  
Avail NTIS HC \$6.00/MF \$0.95

An approach is presented for the transformation function  $\sigma_{\text{sub } x}$  which avoids both sublayer and substructure hypotheses of compressible turbulent boundary layers. Agreement between theory and experiment was obtained using a modification of skin friction principles. Thermodynamic behavior is approximately described by a modified Crocco integral which accounts for non-unit Prandtl number, and variable pressure and/or wall temperature. The boundary layer parameters of the transformed flow were calculated by a method based on the integral equations for momentum and mechanical energy. The calculation method was applied to a variety of turbulent boundary layers with and without pressure gradient. Author

**N72-20279#** Rhode Island Univ., Kingston

**A SIMPLE ANALYSIS OF TWO DIMENSIONAL TURBULENT SKIN FRICTION WITH ARBITRARY WALL AND FREE-STREAM CONDITIONS**

Frank M. White and George H. Christoph. In AGARD Turbulent Shear Flows Jan. 1972 10 p refs. Supported by the AF (See N72-20273 11-12)  
Avail NTIS HC \$6.00/MF \$0.95

An approach is proposed for an approximate analysis of the two-dimensional turbulent boundary layer under a wide variety of arbitrary conditions. An effective formula is developed for the law-of-the-wall which accounts for all of the different parameters considered. The wall law is combined with the differential momentum equation into a single first-order ordinary differential equation for the skin friction coefficient, suitable for computer or graphical solution and, in special cases, closed form solutions. Examples are given covering combinations of eight different effects: pressure gradient, heat transfer, compressibility, roughness, wall transpiration, transverse curvature, longitudinal curvature, and aqueous polymer solutions. The results indicate that the theory is not only the simplest existing analysis of the turbulent boundary layer but one of the most accurate. Author

**N72-20280#** Karlsruhe Univ. (West Germany)

**AN EDDY VISCOSITY BASED ON THE SECOND PRINCIPAL INVARIANT OF THE DEFORMATION TENSOR**

Willy Schoenauer. In AGARD Turbulent Shear Flows Jan. 1972 10 p refs (See N72-20273 11-12)  
Avail NTIS HC \$6.00/MF \$0.95

Equations were derived for the time mean values of incompressible turbulent flow. The stress tensor was considered to be a function of the deformation tensor. The assumption of spatial homogeneity and isotropy led to eddy viscosity dependence on the second principal invariant of the deformation tensor. The eddy viscosity function contains empirical coefficients which must be determined from measurements of turbulent equilibrium flows. Nonequilibrium flows were then described by relaxation equations. Equations for the turbulent boundary layer were derived. The empirical coefficients of the eddy viscosity function were determined for flat plate flow. Author

**N72-20281#** Virginia Polytechnic Inst., Blacksburg, Dept. of Aerospace Engineering.

**EFFECTS OF STRONG AXIAL PRESSURE GRADIENTS ON TURBULENT BOUNDARY LAYER FLOWS**

Clark H. Lewis, E. W. Miner, and E. C. Anderson. In AGARD Turbulent Shear Flows Jan. 1972 14 p refs (See N72-20273 11-12)  
(Contract NAS1-9337)

(NASA-CR-125903) Avail: NTIS CSCL 20D

Comparisons are made between predictions for nonreacting turbulent boundary layer flow using a finite difference method, and integral methods used to predict compressible turbulent flows with pressure gradient and wall heat transfer. Both rocket and hypersonic aerodynamic wind tunnel nozzles are considered. Cooled and heated walls were studied. Van Dries and Reichardt's models were considered in a two-layer eddy viscosity scheme. Under heated wall conditions (i.e. wall temperature greater than the adiabatic wall temperature), strong coupling effects were found between wall heating and axial pressure gradients. For cooled wall conditions, predictions of velocity and temperature profiles downstream from regions of strong favorable pressure gradients were in good agreement with limited experimental profile data. Limitations in the use of boundary layer transformations for heated wall flows are presented. A computer program was developed to predict nonreacting and equilibrium chemically reacting laminar and/or turbulent boundary layer flows for internal (nozzle) and external two-dimensional and axisymmetric flows. Author

**N72-20282#** Instituto Superior Tecnico, Lisbon (Portugal)

**MACH NUMBER EFFECTS IN TURBULENT FLOW**

J. J. D. Domingos. In AGARD Turbulent Shear Flows Jan. 1972 10 p refs (See N72-20273 11-12)  
Avail NTIS HC \$6.00/MF \$0.95

Starting from fundamental assumptions of microscopic thermodynamics and continuum mechanics, the existence of a velocity potential for the flow of viscous fluids was proved as a general property. The implications are discussed and the role of compressibility as an essential feature of turbulence, either in subsonic or supersonic flows, is stressed. The apparently contradictory consequence of zero vorticity in flows which are derived from a potential is clarified through a discussion of concepts implicitly assumed in the usual definitions of mean density, mean velocity, and thermodynamic equations of state. The results are applicable to general supersonic viscous flows, because the theory is concerned with instantaneous velocity fields, without separation into mean and turbulent quantities. The solutions found are asymptotically exact solutions of the time-dependent three-dimensional Navier-Stokes equations for a viscous and compressible fluid which follows a polytropic evolution. Author

**N72-20283#** Avco Corp., Wilmington, Mass. Avco Systems Div.

**A TWO LAYER MODEL OF HIGH SPEED, THREE DIMENSIONAL TURBULENT BOUNDARY LAYERS AND SUPERCRITICAL BOUNDARY LAYER INVISCID FLOW INTERACTIONS**

Barry L. Reeves. In AGARD Turbulent Shear Flows Jan. 1972 21 p refs (See N72-20273 11-12)  
Avail NTIS HC \$6.00/MF \$0.95

A two-layer model of the three-dimensional compressible turbulent boundary layer was developed which is applicable to flows with pressure gradient and surface mass transfer. The model is based on the small cross flow approximation in which the spreading metric is determined by the inviscid streamline pattern. A modified Mangler transformation was employed which permits transformation of the boundary layer equations to a two-dimensional form without transforming the turbulent stress or heat flux. The computational speed of the method is rapid enough to enable equations for the inviscid stream deflection to be coupled with method used for calculations of strong (supercritical) interactions, such as in the region downstream of the critical point in reattaching flows or in regions of strong

blowing. Solution of the inner (wall) layer for the velocity, enthalpy, stress and heat flux was obtained using mixing length theory and the thin layer Couette model. This solution led to a generalized compressible law of the wall with mass injection. In the outer wake layer an integral moment method was used along with appropriate matching conditions with the inner layer. Several solutions and experimental comparisons are presented. Results are also presented for relaxing flows where  $C_{sub} f$  and  $(2C_{sub} H)/C_{sub} f$  initially are far from their equilibrium values.

Author

**N72-20284#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France).

**APPLICATION OF AN IMPROVED MIXING LENGTH MODEL TO THE STUDY OF THREE DIMENSIONAL BOUNDARY LAYERS [APPLICATION D'UN SCHEMA ANEJOURE DE LONGUEUR DE MELANGE A L'ETUDE DES COUCHES LIMITES TURBULENTES TRIDIMENSIONNELLES]**

J. Cousteix, C. Quemard, and R. Michel. In AGARD Turbulent Shear Flows. Jan. 1972. 11 p. refs. In FRENCH, ENGLISH summary (See N72-20273 11-12). Avail. NTIS HC \$6.00/MF \$0.95

An improved mixing-length model, previously applied to two-dimensional flow, is extended to cover the three-dimensional case, relying on the assumption that the turbulent shear stress acts in the same direction as the laminar. It is used to work out similar solutions to the local equations of a turbulent boundary layer with small cross-flow. In a compressible fluid with arbitrary pressure gradients, a digital routine enables sets of transverse and longitudinal boundary-layer profiles and the wall skin-friction components to be determined as a function of flow parameters expressing the influence of pressure gradients. A comparison with experimental results shows a measure of agreement. The model offers the requisite hypotheses on which to build an integral method of computing three-dimensional turbulent boundary layers.

Author

**N72-20285#** National Aerospace Lab., Amsterdam (Netherlands). **A CALCULATION METHOD FOR THREE DIMENSIONAL INCOMPRESSIBLE TURBULENT BOUNDARY LAYERS**

P. Wesseling and J. P. F. Lindhout. In AGARD Turbulent Shear Flows. Jan. 1972. 13 p. refs. (See N72-20273 11-12). Avail. NTIS HC \$6.00/MF \$0.95

A system of partial differential equations which can be used as a mathematical model for three-dimensional incompressible turbulent boundary layers is discussed. Certain mathematical properties of these equations are elucidated. The equations have a finite domain of dependence; this fact simplifies the problem of calculating three-dimensional boundary layer flows. The equations are solved numerically by means of a simple linear explicit finite difference scheme. The choice of an efficient difference scheme is guided by two criteria for the stability of linear difference schemes with constant coefficients. The method is used to calculate several experimental flows.

Author

**N72-20286#** Aeronautical Research Associates of Princeton, Inc., N.J.

**A PROGRESS REPORT ON THE ATTEMPT TO CONSTRUCT AN INVARIANT MODEL OF TURBULENT SHEAR FLOWS**

Coleman duP. Donaldson. In AGARD Turbulent Shear Flows. Jan. 1972. 24 p. refs. (See N72-20273 11-12). (Contract NASw-1868) (NASA-CR-125904). Avail. NTIS CSCL 20D

The results of comparing computations using a tentative model of turbulent shear flows with experimental data are presented for the axially symmetric free jet, the two-dimensional free shear layer, and the flat plate boundary layer. The need for more carefully designed and documented free turbulent flow measurements is discussed in relation to the problem of selecting more refined models. Some observations are also made concerning the application of double correlation closure schemes

to the computation of turbulent flows other than classical incompressible shear layers. In particular, the possibility of other methods of calculating the behavior of chemically reacting turbulent flows is examined.

Author

**N72-20287#** Delaware Univ., Newark.

**A RE-EVALUATION OF ZERO PRESSURE GRADIENT COMPRESSIBLE TURBULENT BOUNDARY LAYER MEASUREMENTS**

James E. Danberg. In AGARD Turbulent Shear Flows. Jan. 1972. 11 p. refs. (See N72-20273 11-12). Avail. NTIS HC \$6.00/MF \$0.95

Compressible turbulent boundary layer velocity and temperature profiles with zero pressure gradient were collected and prepared for computer analysis. An assumed equation for these profiles was chosen allowing four constants to be adjusted by a nonlinear least squares technique. The four constants are: a velocity scale, boundary layer thickness, the constant of the semi-log region and the wake constant. This equation is analogous to Cole's incompressible law of the wall and wake but uses a generalized velocity to account for compressibility. Measurements from 45 adiabatic wall tests were analyzed covering a Mach number range from 2 to 6. Of these profiles, 29 included skin friction balance data which allowed direct evaluation of the universal constant of turbulence (mean value of  $\lambda = .43$ ) through comparison between the shear velocity and the profile velocity scale. The constants of the semi-log and the wake region were found to be independent of Reynolds and Mach numbers. A similar analysis was carried out for the limited number of total temperature profiles.

Author

**N72-20288#** Royal Aircraft Establishment, Bedford (England).

**SOME BOUNDARY LAYER MEASUREMENTS ON A FLAT PLATE AT MACH NUMBERS FROM 2.6 TO 4.5**

D. G. Mabey, H. U. Meier (Deutsche Forschungs- und Versuchsanstalt fuer Luft und Raumfahrt, Goettingen), and W. G. Sawyer. In AGARD Turbulent Shear Flow. Jan. 1972. 11 p. refs. (See N72-20273 11-12).

Avail. NTIS HC \$6.00/MF \$0.95

An experimental investigation of the turbulent boundary layer on a large, thermally insulated flat plate is reported, in which Mach number and total temperature profiles and shear stress at the wall were measured. The measured velocity profiles are found to be in good agreement with theoretical treatments. Similarly, the measured skin-friction coefficients are predicted flat-plate skin-friction laws. The form of the total temperature profile close to the wall suggests an increase in turbulent Prandtl number as the wall is approached. At all conditions, the wall temperature was found to be higher than would be expected in adiabatic flow conditions, while there was a substantial deficit of enthalpy flux within the boundary layer.

Author

**N72-20289#** National Aeronautical Establishment, Ottawa (Ontario).

**COMPARISONS BETWEEN SOME HIGH REYNOLDS NUMBER TURBULENT BOUNDARY LAYER EXPERIMENTS AT MACH 4, AND VARIOUS RECENT CALCULATION PROCEDURES**

D. J. Peake, G. Brakmann (McGill Univ.), and J. M. Romoskie (McGill Univ.). In AGARD Turbulent Shear Flows. Jan. 1972. 70 p. refs. (See N72-20273 11-12). Avail. NTIS HC \$6.00/MF \$0.95

The objective was to assess the influence of streamwise pressure gradients upon two dimensional compressible turbulent boundary layers at high Reynolds numbers, in the absence of end wall effects and longitudinal curvature effects. Boundary layers recovering to equilibrium conditions were emphasized. Measurements were made at a Mach 4 of pressure distribution, local skin friction, and boundary layer profiles along the internal surface of a parallel, circular cross-section duct. The Reynolds number based on the duct length of 33 inches was almost 50 million. Results from three experiments are presented, namely a near zero pressure gradient flow, an adverse pressure gradient



case, and a flow relaxing downstream of a step-induced separation. The boundary layer predictions of all the methods were in reasonable agreement with experiment. The outstanding exception was the discrepancy observed between the calculated and experimental skin friction results in the adverse pressure gradient flow, which was attributed tentatively to the static pressure gradient across the boundary layer in the region of the streamwise pressure increase. Author

**N72-20290#** Johns Hopkins Univ., Baltimore, Md.  
**THE STRUCTURE OF TURBULENCE IN SHEAR FLOWS**  
Leslie S. G. Kovasznay. In AGARD Turbulent Shear Flows. Jan. 1972. 14 p. refs (See N72-20273 11-12)  
(Contract F44620-69-C-0023)  
Avail. NTIS HC \$6.00/MF \$0.95

Results obtained by flow visualization techniques have given inspiration for devising plausible models rather than have provided numerical data to be compared with experiments. Hot-wire anemometer records, especially by employing appropriate signal processing techniques have given quantitative data that can be used for direct comparison with theoretical predictions. Theoretical possibilities are reviewed, and arguments are presented for favoring a model consisting of random sprinkled, but deterministic flow structures against models based on travelling waves. A suggestion for a possible form of mean flow predictions schemes is outlined. Author

**N72-20291#** ARO, Inc., Arnold Air Force Station, Tenn.  
**FREE TURBULENT MIXING: A CRITICAL EVALUATION OF THEORY AND EXPERIMENT**  
Philip T. Harsha. In AGARD Turbulent Shear Flows. Jan. 1972. 11 p. refs (See N72-20273 11-12)  
(Contract F40600-71-C-0002. AF Proj. 9711)  
Avail. NTIS HC \$6.00/MF \$0.95

A group of models for the turbulent shear stress, ranging from the classical Prandtl mixing length theory to the kinetic energy models, are systematically confronted with a broad range of experimental data. Two sets are developed: (1) those models suitable for engineering use, and (2) the models which show promise of becoming applicable with further development to turbulent free mixing. Author

**N72-20292#** California Univ., La Jolla. Dept. of Aerospace and Mechanical Engineering Sciences  
**JET TURBULENCE: DISSIPATION RATE MEASUREMENTS AND CORRELATIONS**  
Carl A. Friehe, C. W. Van Atta, and Carl H. Gibson. In AGARD Turbulent Shear Flows. Jan. 1972. 7 p. refs (See N72-20273 11-12)  
(Contract F44620-68-C-0010. Proj. THEMIS)  
Avail. NTIS HC \$6.00/MF \$0.95

A correlation of the mean rate of dissipation on the center-line in terms of the orifice Reynolds number and axial position is established. Measurements of the velocity and velocity derivative are described for a jet of orifice Reynolds number of  $1.2 \times 10^5$  to the 5th power. The spectrum of the square of the velocity derivative was found to be similar to those obtained for atmospheric boundary layer flows at very large Reynolds numbers when normalized with Kolmogoroff length and time scales. Spectra of higher order moments of the velocity derivative are also presented and compared to Novikov's predictions of the power law subranges. Author

**N72-20293#** Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany)  
**VELOCITY AND DENSITY MEASUREMENTS IN A FREE JET**  
O. H. Wehrmann. In AGARD Turbulent Shear Flows. Jan. 1972. 9 p. refs (See N72-20273 11-12)  
Avail. NTIS HC \$6.00/MF \$0.95

The fluctuating properties in a turbulent flow are due to convection, diffusion, production, dissipation, and pressure

transport. To perform an energy balance, not only velocity terms have to be measured, but also the pressure or density components of the pressure transport term. Velocity fluctuations can be measured by the hot-wire technique; in contrast to this, the local measurement of the density fluctuations presents a certain problem, especially if the disturbance of the flow field by a density measuring would have to be kept as small as possible. To obtain a local measurement, a focussed laser beam Mach-Zehnder interferometer was used. The flow measurements were made for the flow field behind a 2.5 cm nozzle at a flow velocity of 43 m/sec. The flow in the center of the nozzle at the exit plane was laminar or made turbulent by the insertion of a screen. Author

**N72-20294#** Technical Univ. of Denmark, Lyngby. Dept. of Fluid Mechanics  
**AN EXPERIMENTAL INVESTIGATION OF CURVED TWO-DIMENSIONAL TURBULENT JETS**  
C. Schartzbach. In AGARD Turbulent Shear Flows. Jan. 1972. 12 p. refs (See N72-20273 11-12)  
Avail. NTIS HC \$6.00/MF \$0.95

Hot-wire measurements of mean velocity and normal turbulent stress in the direction of flow are presented for the flow field generated by a plane jet reattaching to a flat plate adjacent to the jet nozzle. Measurements were made in longitudinal and lateral traverses of the curved jet flow and in the two wall jet flows. Measurements were made in two series for thirteen different positions on the adjacent plate thereby providing data for differing values of jet curvature and jet pathlengths. Integral methods were used on the experimental data to evaluate the effect of jet curvature on the entrainment along the external and internal boundaries of the curved jet. Author

**N72-20295#** California Inst. of Tech., Pasadena  
**THE EFFECT OF DENSITY DIFFERENCE ON THE TURBULENT MIXING LAYER**  
Garry V. Brown and Anatol Roshko. In AGARD Turbulent Shear Flows. Jan. 1972. 12 p. refs. Supported by ONR (See N72-20273 11-12)  
Avail. NTIS HC \$6.00/MF \$0.95

An experimental study was made of the turbulent mixing layer between two streams of different gases, especially nitrogen and helium. This was made in a flow apparatus, designed to produce good quality flow at pressures up to 10 atmospheres with run times as low as 1 or 2 seconds. High speed measurement techniques, including a density probe, were used. Shadowgraphs of the turbulent mixing layer reveal a large scale structure similar to that in the late stages of instability development in a laminar free shear layer. The similarity properties of the mixing layers are established from profiles of mean velocity and density, and from these the basic flow parameters are computed: spreading rate, dissipation rate, shear stress distribution. It is found that a large density ratio (e.g., 7.1) in the two streams does not have a great effect on the spreading rate; this contrasts with the large effect of Mach number on the turbulent spreading of a free shear layer at the edge of a supersonic flow. A brief analysis compares the effects of density nonuniformities in low speed flow and those due to compressibility at high Mach number. Author

**N72-20296#** Defence Research Establishment Valcartier (Quebec)  
**FLUID DYNAMIC PROPERTIES OF TURBULENT WAKES OF HYPERSONIC SPHERES**  
J. G. G. Dionne, D. Heckman, C. Lahaye, L. Sevigny, and L. Tardif. In AGARD Turbulent Shear Flows. Jan. 1972. 13 p. refs (See N72-20273 11-12)  
(ARPA Order 133)  
Avail. NTIS HC \$6.00/MF \$0.95

Representative data, concerning the mean behavior of velocity and density in the wakes of hypersonic spheres launched at Mach 13 and a pressure times specific density of 20 torr-inches, are given. The variation with axial distance of the

velocity, density, and temperature defects and of the velocity and density wake radii are given and are compared with other similar data and with schlieren data obtained under the same conditions. Data on turbulent characteristics such as velocity fluctuations, ionization scale lengths and wake intermittency are also given. Finally, the total momentum in the wake is estimated from the measured velocity and mass density distributions.

Author

**N72-20297#** Avco Everett Research Lab., Everett, Mass.  
**MEASUREMENTS OF THE INSTANTANEOUS SPATIAL DISTRIBUTION OF A PASSIVE SCALAR IN AN AXISYMMETRIC TURBULENT WAKE**

Arthur M. Schneiderman. In AGARD Turbulent Shear Flows Jan 1972. 12 p. refs (See N72-20273 11-12)  
 (Contract F04701-70-C-0128)

Avail NTIS HC \$6.00 MF \$0.95

The spatial mixing field in the turbulent wake of a longitudinally aligned truncated cylinder at a Mach number of 2.5 and a Reynolds number of 1 million (based on diameter) is observed experimentally using the laser planogram technique. The instantaneous spatial distribution of a tracer material introduced at the model is characterized statistically by estimates of the probability density function, energy spectrum and autocovariance coefficient of the measured fluctuations. Wake axis measurements over the region from 138 to 182 body diameters yield turbulent concentration fluctuations of 25% and skewness and kurtosis of +0.18 and +0.16, respectively. A centerline intermittency of approximately 82% is observed. A classical turbulence spectrum with a well defined break from a flat to a  $k^{-5/3}$  to the minus 5/3 power inertial subrange is found. The autocovariance coefficient yields a macroscale which is approximately half the transverse scale length. The wake boundary is observed to be substantially more contorted than had previously been suspected.

Author

**N72-20298#** Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Göttingen (West Germany)

**RECENT ATTEMPTS TO DEVELOP A GENERALLY APPLICABLE CALCULATION METHOD FOR TURBULENT SHEAR FLOW LAYERS**

J. C. Rotta. In AGARD Turbulent Shear Flows Jan 1972. 11 p. refs (See N72-20273 11-12)

Avail NTIS HC \$6.00 MF \$0.95

Calculation methods are discussed, which are based on the differential equations for the Reynolds stresses. The considerations restrict themselves to two-dimensional flow fields, for which the usual boundary layer approximations apply. In many of the proposed methods of this kind, the equation for the kinetic fluctuation energy plays a central role. The transport equation for the Reynolds shear stress includes as special cases Prandtl's eddy viscosity relation and Bradshaw's assumption of a constant ratio of shear stress to kinetic fluctuation energy. A differential equation for the integral length scale is derived from Navier-Stokes equations, and the closure assumptions are given. It turns out that the simplified version of the length scale equation used by some authors is not capable of reproducing the characteristics of different kinds of flows. The main reason for this shortcoming is found in an oversimplification of the turbulence production term of the length scale equation. The arguments are illustrated by calculated results.

Author

**N72-20299#** Naval Ordnance Lab., White Oak, Md.  
**AN EXPERIMENTAL STUDY OF THE COMPRESSIBLE TURBULENT BOUNDARY LAYER WITH AN ADVERSE PRESSURE GRADIENT**

Robert L. P. Vignani, Roland F. Lee, and William L. Yanta. In AGARD Turbulent Shear Flows Jan 1972. 10 p. refs (See N72-20273 11-12)

Avail NTIS HC \$6.00 MF \$0.95

The results of a detailed experimental investigation of the compressible turbulent boundary layer in an adverse pressure

gradient regime are presented. The studies were conducted on a flat nozzle wall for Mach numbers between 4.1 and 4.9, at momentum thickness Reynolds numbers from 5600 to 69,000 and at wall-to-adiabatic-wall temperature ratios of 1.0 and 0.8. Complete and often redundant profile measurements were taken with Pitot and static pressure probes and conical equilibrium and fine-wire temperature probes. The wall shear and surface heat transfer were measured directly with a skin-friction balance and a heat-transfer gage. The effect of the adverse-pressure gradient flow on the boundary-layer flow structure, friction drag, and heat transfer, as compared with zero- and favorable-pressure gradient flow, is discussed. A test showing the effect of nozzle throat cooling on the downstream boundary layer is also reported. This throat cooling caused significant changes in the downstream temperature profiles and recovery factor with no effect on the local wall shear.

Author

**N72-20300#** Ballistic Research Labs., Aberdeen Proving Ground, Md.

**THE SUPERSONIC TURBULENT BOUNDARY LAYER IN AN ADVERSE PRESSURE GRADIENT: EXPERIMENT AND DATA ANALYSIS**

Walter B. Sturek and James E. Danberg (Delaware Univ. Newark). In AGARD Turbulent Shear Flows Jan 1972. 13 p. refs (See N72-20273 11-12)

Avail NTIS HC \$6.00 MF \$0.95

Experimental measurements of the profile characteristics of the supersonic turbulent boundary layer in a region of moderate adverse pressure gradient along a two-dimensional isentropic ramp model are reported. The data are for a closely adiabatic wall at a tunnel nozzle setting of  $M = 3.54$ . Detailed surveys of impact pressure, static pressure and total temperature were made and wall shear stress was measured using the Preston tube technique. In addition to the mean profile data, fluctuation data were obtained using constant temperature hot-wire anemometry in the zero pressure gradient flow upstream of the ramp model and in the adverse pressure gradient flow along the ramp model. Turbulent boundary layer equations applicable to compressible flow over a surface with longitudinal curvature are analyzed. Corrections for longitudinal curvature to the equation for conservation of streamwise momentum are shown to be small and of the same order of magnitude as the contribution of the wall shear stress. The data are shown to correlate in law of the wall and velocity defect dimensionless coordinates using an integral compressibility transformation that follows directly from Prandtl's mixing length approximation of the Reynolds stress. Eddy viscosity and mixing length distributions for the zero pressure gradient boundary layer were determined directly from the experimental data and agree qualitatively with previously published findings. The measured value of skin friction coefficient is 20 percent less for the flow over the ramp model than for the zero pressure gradient flow upstream.

Author

**N72-20301#** Imperial Coll. of Science and Technology, London (England). Aeronautics Dept.  
**TURBULENT BOUNDARY LAYERS AT SUPERSONIC AND HYPERSONIC SPEEDS**

G. T. Coleman, G. M. Elfstrom, and J. L. Stollery. In AGARD Turbulent Shear Flows Jan 1972. 9 p. refs (See N72-20273 11-12)

Avail NTIS HC \$6.00 MF \$0.95

The growth of a compressible turbulent boundary layer over flat plate and compression corner models was studied at a Mach number of 9. Local Mach numbers between 3 and 9 were achieved on a flat plate by varying the incidence from 0 to 26.5 deg. The local unit Reynolds numbers used were between 150,000 and 700,000. The measurements, which include pressure and heat transfer rate distributions and pitot pressure profiles across the boundary layer, extend the range of existing data and are used to test some current predictive methods and to emphasize some features of lower Mach number flows. Heat transfer rate distributions at Mach numbers of 3, 5, and 9 show an increasing discrepancy between experiment and theory as the Mach number rises, the data being higher than the predicted

value but approaching it asymptotically with increasing momentum thickness Reynolds number ( $Re_{\theta}$ ). The boundary layer profiles taken at Mach 9 grew fuller as  $Re_{\theta}$  decreased, both of these results are associated with the slow development of the wake component of the turbulent boundary layer profile at high Mach numbers. Author

**N72-20302#** Queen Mary Coll., London (England)  
**AN EXPERIMENTAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER ALONG A STREAMWISE CORNER**  
O. O. Mojola and A. D. Young. In AGARD Turbulent Shear Flows Jan. 9, 1972. 9 p. refs. (See N72-20273 11-12)  
Avail. NTIS HC \$6.00 MF \$0.95

A selection of results are presented of an extensive experimental investigation of steady incompressible turbulent boundary layer along a smooth 90 degree streamwise corner, formed by a pair of identical intersecting flat plates, with the freestream velocity directed parallel to the cornerline. Detailed explorations of the flow with and without external pressure gradients, included the determination of static pressure fields, the mean velocities, wall shear stresses, and the components of the Reynolds (turbulent) stress tensor. A secondary flow towards the corner along the plane of symmetry and outwards from it close to the walls forming the corner is a vital and characteristic feature and is clearly reflected in the mean and turbulence flow measurements. In particular, it modifies the relations between the shear stress components and turbulence energy and mean velocity distribution so as to make any simple extension of current methods of turbulent boundary layer prediction unlikely to be applicable in such a flow. Author

**N72-20303#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)  
**INJECTION OF A TURBULENT BOUNDARY LAYER WALL WITH A STRANGE GAS (COUCHE LIMITE TURBULENTE AVEC INJECTION A LA PAROI D'UN MEME GAZ OU D'UN GAZ ETRANGER)**  
T. Lili and R. Michel. In AGARD Turbulent Shear Flows Jan. 1972. 10 p. refs. In FRENCH. ENGLISH summary. (See N72-20273 11-12)  
Avail. NTIS HC \$6.00 MF \$0.95

An improved mixing-length model is applied to the theoretical determination of a turbulent boundary layer, with transfer of fluid at the wall, and the results are compared point by point with available experimental evidence. In the incompressible field, there are first provided some solutions to the local equations of an equilibrium boundary layer to define the requisite set of velocity profiles and skin friction law for an air injection with pressure gradient. Next, the velocity and concentration profiles are worked out for foreign gas injected. Lastly, the solution is extended to cover the general case of a compressible fluid, leading to a systematic set of results for the effect of injection upon skin friction and heat transfer shown as a function of Mach number and wall temperature. Author

**N72-20304#** California Inst. of Tech., Pasadena  
**A SURVEY OF DATA FOR TURBULENT BOUNDARY LAYERS WITH MASS TRANSFER**  
Donald Colts. In AGARD Turbulent Shear Flows Jan. 1972. 15 p. refs. (See N72-20273 11-12)  
Avail. NTIS HC \$6.00 MF \$0.95

A critical survey is made of available experimental data on turbulent boundary layers with mass transfer in the absence of complicating factors such as compressibility and pressure gradient. Two approaches to the data show particular promise. The first is the mixing-length approach, which leads (as is well known) to a set of modified coordinates such that the classical similarity laws outside the sublayer seem to remain valid down to the last detail, at least for moderate values of suction or blowing. The second approach is more original; it is an attempt to generalize the kind of analysis often used to develop similarity laws for free shear flows such as wakes or jets, while preserving intact an argument which extends these ideas to the case of boundary layer

flow. The essential step is the definition of a characteristic velocity (qua friction velocity) in terms of a characteristic stress (qua wall stress) which occurs somewhere in the layer. A strong precedent for such a step can be found in the usual treatment of surface roughness. So far, the best choice for the characteristic stress seems to be some kind of average value for the sublayer. Author

**N72-20305#** Stanford Univ., Calif. Dept. of Mechanical Engineering  
**THE SUPPRESSION OF SHEAR LAYER TURBULENCE IN ROTATING SYSTEMS**

James P. Johnston. In AGARD Turbulent Shear Flows Jan. 1972. 9 p. refs. (See N72-20273 11-12)  
(Grants NSF GK-2533, NSF GK-16450)  
Avail. NTIS HC \$6.00 MF \$0.95

Stabilization of turbulent boundary layer type flows by the action of Coriolis forces engendered by system rotating is studied. Experiments on fully-developed, two-dimensional flow in a long, straight channel that was rotated about an axis perpendicular to the plane of mean shear are reviewed to demonstrate the principle effects of stabilization. In particular, the delay of transition to turbulence on the stabilized side of the channel to high Reynolds number as the rotating number is increased is demonstrated. A simple method, that utilizes the eddy Reynolds number criterion of Bradshaw, is employed to show that rotating induced suppression of transition may be predicted for the channel flow case. The applicability of the predictive method to boundary layer type flows is indicated. Author

**N72-20306#** Lyon Univ. (France)  
**DEVELOPMENT OF A TURBULENT BOUNDARY LAYER ON A FLAT PLATE IN AN EXTERNAL TURBULENT FLOW**  
G. Charnay, G. Comte-Bellot and J. Mathis. In AGARD Turbulent Shear Flows Jan. 1972. 9 p. refs. (See N72-20273 11-12)  
Avail. NTIS HC \$6.00 MF \$0.95

The development of a turbulent boundary layer on a flat plate was experimentally investigated in the presence of an external turbulent flow generated by grids. With reference to a turbulent boundary layer evolving in an undisturbed flow the following results were observed when the external turbulence level is increasing: (1) the boundary layer grows more rapidly; (2) the wall shear stress is higher; (3) in the outer region of the layer the mean velocity profile becomes flatter and the law of the wake is modified. In the same region the turbulent levels are increased, and the turbulent shear stress and the turbulent kinetic energy production become larger. Various integral length scales of the external turbulent flow were also used. A discernable effect was observed on the integral scales of the boundary layer only. A rearrangement of the external isotropic turbulence, due to the straining process of the mean existing velocity gradient in the boundary layer is tentatively proposed. Author

**N72-20307#** Imperial Coll. of Science and Technology, London (England) Dept. of Aeronautics  
**SOME MEASUREMENTS OF THE DISTORTION OF TURBULENCE APPROACHING A TWO DIMENSIONAL BODY**  
P. W. Bearman. In AGARD Turbulent Shear Flows Jan. 1972. 11 p. refs. (See N72-20273 11-12)  
Avail. NTIS HC \$6.00 MF \$0.95

A description is given of the distortion of grid generated turbulence as it approaches the stagnation region of a two dimensional body. When  $L_{sub} \times D$  is much greater than 1 (where  $L_{sub}$  is the scale of turbulence and  $D$  is a typical body dimension) along the mean stagnation streamline the longitudinal component of the velocity fluctuations attenuates like the mean flow. Whereas if  $L_{sub} \times D$  is much less than 1 the turbulence is distorted by the mean flow field and the longitudinal component of the velocity fluctuations will be amplified due to the vortex

stretching. When  $L \text{ sub } x/D = O(1)$  a combination of these effects is found with attenuation of energy at low wave numbers and amplification at high wave numbers. Measurements of the pressure fluctuations at the stagnation point show that at low wave numbers the level of the pressure fluctuations can be predicted by assuming the turbulence to be irrotational. Author

**N72-27293#** Advisory Group for Aerospace Research and Development, Paris (France).

#### NUMERICAL METHODS IN FLUID DYNAMICS

J. J. Smolderen, ed. May 1972. 328 p. refs. Partly in ENGLISH and partly in FRENCH.

(AGARD-LS-48) Avail. NTIS HC \$18.50

Numerical analysis and approximation are considered for gas and fluid flow problems in fluid dynamics. Navier-Stokes and other equations of motion are discussed, as well as various finite element methods. For individual titles, see N72-27294 through N72-27308.

**N72-27294** Von Karman Inst. for Fluid Dynamics, Rhode Saint Genese (Belgium).

#### INTRODUCTORY FARKS

J. J. Smolderen. In AGARD Numerical Methods in Fluid Dyn. May 1972. 8 p. (For availability see N72-27293 18-12)

The basic mathematical problems of fluid mechanics are reviewed and the various numerical techniques available to solve partial differential equations are presented. Their advantages and limitations are briefly discussed. Author

**N72-27295** Paris Univ. (France).

#### ON THE NUMERICAL APPROXIMATION OF SOME EQUATIONS ARISING IN HYDRODYNAMICS

J. L. Lions. In AGARD Numerical Methods in Fluid Dyn. May 1972. 13 p. refs. (For availability see N72-27293 18-12)

Examples are developed of equations arising in hydrodynamics for the following: (1) approximation of systems which are not of the Cauchy-Kowalewski type by systems of that type; (2) the possibilities of splitting the systems of the Cauchy-Kowalewski type; and (3) the splitting of coupled systems. Author

**N72-27296** Paris Univ. Orsay (France).

#### APPROXIMATION OF NAVIER-STOKES EQUATIONS

R. Temam. In AGARD Numerical Methods in Fluid Dyn. May 1972. 6 p. refs. (For availability see N72-27293 18-12)

Methods of approximation of the full Navier-Stokes equations are discussed. The problem considered is the unsteady flow (and sometimes the steady flow) of an incompressible viscous fluid in a bounded domain. The problem possesses a unique solution in the case of a two-dimensional flow. In the case of a three-dimensional flow, the problem possesses at least one solution but uniqueness is known only when the vectors  $f$  and  $u \text{ sub } 0$  are sufficiently small for  $Re$  fixed (laminar flow). Three kinds of approximation methods are described: (1) the penalty method; (2) perturbation and fractional step method; and (3) the fractional step method. Author

**N72-27297** Laval Univ. (Quebec).

#### THE APPROXIMATION OF NAVIER-STOKES EQUATIONS FOR VISCOUS INCOMPRESSIBLE FLUIDS [SUR L'APPROXIMATION DES EQUATIONS DE NAVIER-STOKES DES FLUIDES VISQUEUX INCOMPRESSIBLES]

M. Fortin and R. Temam. (Paris Univ. Orsay). In AGARD Numerical Methods in Fluid Dyn. May 1972. 7 p. refs. In FRENCH. (For availability see N72-27293 18-12)

The problem considered is that of stationary flow of a viscous incompressible fluid in a bounded domain  $\Omega$ . If the vector  $u$  is designated as the velocity vector,  $p$  as pressure, and  $f$  as the given forces, the equations of motion are written in the classical manner in vector, integral form. Initial and limiting conditions are also given. The method discussed here is an interpretation of the fractional step method. Translated by K. P. D.

**N72-27298** Laval Univ. (Quebec).

#### NUMERICAL SOLUTION OF STEADY STATE NAVIER-STOKES EQUATIONS

M. Fortin. In AGARD Numerical Methods in Fluid Dyn. May 1972. 8 p. refs. (For availability see N72-27293 18-12)

The Navier-Stokes equations of a viscous incompressible fluid in a bounded domain are considered. Only two-dimensional cases are treated but some results and all numerical schemes may be extended to the three-dimensional flow. Existence and uniqueness of solutions are discussed. The results, especially those concerning uniqueness, are used to explain the difficulties encountered in the convergence proofs of the methods. Author

**N72-27299** International Business Machines Corp., San Jose, Calif.

#### NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS AT HIGH REYNOLDS NUMBERS AND THE PROBLEM OF DISCRETIZATION OF CONVECTIVE DERIVATIVES

Jacob E. Fromm. In AGARD Numerical Methods in Fluid Dyn. May 1972. 47 p. ref. (For availability see N72-27293 18-12)

The essentials of numerical computation of time-dependent nonlinear fluid flows are discussed. The case under consideration is that of incompressible flow with viscosity described in terms of a vorticity and stream function. Author

**N72-27300** Polytechnic Inst. of Brooklyn, Farmingdale, N.Y. Graduate Center.

#### NUMERICAL ANALYSIS OF VISCOUS ONE-DIMENSIONAL FLOWS

G. Moretti and M. D. Salas. In AGARD Numerical Methods in Fluid Dyn. May 1972. 20 p. refs. Presented at Meeting on Appl. of Numerical Methods in *M. J. Gasdyn.* Novosibirsk, USSR, 17-24 Aug. 1969. (For availability see N72-27293 18-12)

The flow of a viscous, heat-conducting gas produced by an accelerating piston is analyzed numerically. The formation of a shock in a viscous flow is studied. A discussion of accuracy and practicality of a numerical analysis of the problem is given. It is concluded that the assumption of a shock as a sharp discontinuity is the only practical way to handle flows whose Reynolds number per unit length is higher than 100. Author

**N72-27301** Polytechnic Inst. of Brooklyn, Farmingdale, N.Y. Graduate Center.

#### A CRITICAL ANALYSIS OF NUMERICAL TECHNIQUES. THE PISTON-DRIVEN INVISCID FLOW

G. Moretti. In AGARD Numerical Methods in Fluid Dyn. May 1972. 31 p. refs. (For availability see N72-27293 18-12) (Contract Nonr-839(38); ARPA Order 529)

An analysis of procedures for the computation of one-dimensional shocked flow was made in order to show the inconveniences of computing finite differences across a discontinuity and to prove that the use of the equations of motion in conservation form does not make the results more accurate. A technique was developed to treat one-dimensional inviscid problems, and it is applied to the problem of an accelerating piston. Ways to predict the formation of a shock and to follow its evolution are given. Author

**N72-27302** Polytechnic Inst. of Brooklyn, Farmingdale, N.Y. Graduate Center.

#### TRANSIENT AND ASYMPTOTICALLY STEADY FLOW OF AN INVISCID, COMPRESSIBLE GAS PAST A CIRCULAR CYLINDER

G. Moretti. In AGARD Numerical Methods in Fluid Dyn. May 1972. 19 p. refs. (For availability see N72-27293 18-12) (Contract DAHCO4-69-C-0077)

A numerical analysis is made of the inviscid flow produced by a cylinder which accelerates from a state of rest to a constant supersonic speed in a gas at rest. All features of the

numerical solution are explained on physical grounds. Ways are suggested to compute steady subsonic flows around obstacles with a maximum accuracy and a minimum computational time.

Author

**N72-27303** Polytechnic Inst of Brooklyn, Farmingdale, N.Y. Graduate Center  
**THE BLUNT BODY PROBLEM FOR A VISCOUS RAREFIED GAS FLOW**

G. Moretti and M. D. Salas. In AGARD Numerical Methods in Fluid Dyn. May 1972. 15 p. refs. (For availability see N72-27293 18-12)  
 (Contract Nonr-839(34))

A time-dependent technique developed for inviscid blunt body flows was extended to analyze the viscous layer regime (a rarefied gas situation where viscosity affects most of the shock layer but not the shock wave itself). Navier-Stokes equations were used. To maintain accuracy, the (nonlinear) mesh spacing was adjusted automatically to the nature of the velocity distribution between shock and body. In this way, a wide range of Reynolds numbers can be scanned. The technique could also be used at high Reynolds numbers, when the shock layer is practically inviscid and viscous effects are confined to a boundary layer. Discussion of numerical experiments is given.

Author

**N72-27304** Polytechnic Inst of Brooklyn, Farmingdale, N.Y. Graduate Center  
**THE CHOICE OF A TIME DEPENDENT TECHNIQUE IN GAS DYNAMICS**

G. Moretti. In AGARD Numerical Methods in Fluid Dyn. May 1972. 30 p. refs. (For availability see N72-27293 18-12)  
 (Contract Nonr-839(34))

A definition of the word technique, as related to numerical computations of time-dependent problems in gas dynamics, is given. Requirements of accuracy, economy, and flexibility are considered. A technique which attempts to satisfy them is presented. Emphasis is put on the consistency of the numerical procedure with the physical problem. The concepts of consistency, convergence, and truncation error are reexamined. Certain breakdowns in accuracy occurring in regions of continuous flow are explained. The physical role played by discontinuities and its numerical counterpart are discussed.

Author

**N72-27305** Cambridge Univ. (England). Engineering Dept.  
**APPLICATION OF FINITE ELEMENT METHODS IN FLUID DYNAMICS**

D. H. Norrie and G. deVries (Calgary Univ., Alberta). In AGARD Numerical Methods in Fluid Dyn. May 1972. 43 p. refs. (For availability see N72-27293 18-12)

The classification of finite element methods is presented. Generalized Lagrangian and Hermitian shape functions are discussed in relation to the finite element approximation. Variational finite element methods are considered for equilibrium, eigenvalue, and propagation problems. Direct finite element methods are also discussed. Steady and unsteady potential flow, porous media flows, viscous flow, general fluid flows, and other fluid applications are reviewed. The cell finite element method is also considered.

K.P.D.

**N72-27308** Boeing Co., Seattle, Wash.  
**COMPUTATIONAL METHODS FOR INVISCID TRANSONIC FLOWS WITH IMBEDDED SHOCK WAVES**

Egill M. Murman. In AGARD Numerical Methods in Fluid Dyn. May 1972. 36 p. refs. (For availability see N72-27293 18-12)

Time dependent techniques, relaxation methods, and approximate solutions are considered, with emphasis placed on the latest developments. Computing times, accuracy, and proper treatment of shock waves are stressed.

Author

**N72-27307** Freiburg Univ. (West Germany)

**NUMERICAL TREATMENT OF TIME DEPENDENT THREE DIMENSIONAL FLOWS**

K. G. Roesner. In AGARD Numerical Methods in Fluid Dyn. May 1972. 31 p. refs. (For availability see N72-27293 18-12)

The numerical treatment of three-dimensional time-dependent flows of an ideal gas with constant ratio of specific heats was investigated. It is assumed that inside the flow field, no discontinuities occur. As boundaries, fixed or moving rigid body surfaces and shock waves were allowed. This type of gas flow is described by the Euler equations with appropriate initial and boundary conditions. The mathematical tools applied to this gas dynamical problem are: (1) the method of characteristics, and (2) the method of fractional steps. The application of these methods is discussed for some definite problems, one being the time-dependent inlet flow through a nozzle with a three-dimensional shape of its contour, the other the time-dependent supersonic flow around blunt bodies with various shapes of their surfaces. A comparison was made between the two methods with respect to their effectiveness.

Author

**N72-27308** Societe' Grenobleise d'Etude et d'Applications Hydrauliques (France)

**PETULA (PROGRAM FOR TURBULENT OR LAMINAR FLOWS): AN EXAMPLE OF A COMPLEX MATHEMATICAL MODEL IN FLUID MECHANICS [PETULA (PROGRAMME D'ECOLEMENTS TURBULENTS OU LAMINAIRES): UN EXEMPLE DE MODELE MATHEMATIQUE COMPLEXE EN MECANIQUE DES FLUIDES]**

M. F. Gauthier. In AGARD Numerical Methods in Fluid Dyn. May 1972. 13 p. refs. In FRENCH (For availability see N72-27293 18-12)

The model definition, structure, and empirical parameter identification are presented. Limiting conditions and adaptive coordinate systems are considered. Convergence is considered for the nonlinear model.

Transl. by K.P.D.

**N72-33267\*** Advisory Group for Aerospace Research and Development, Paris (France)

**EXPERIMENTS ON MANAGEMENT OF FREE-STREAM TURBULENCE**

R. I. Loehke (Ill. Inst. of Tech., Chicago) and H. M. Nagib (Ill. Inst. of Tech., Chicago). Sep. 1972. 113 p. refs.  
 (AGARD-R 598). Avail. NTIS HC \$7.75. CSCL 200

The effects of various passive devices (screens, perforated plates, porous foam, and honeycomb-like matrices) formed with closely packed plastic drinking straws on free stream turbulence and mean velocity profiles are studied in air with hot wire anemometry and in water using hydrogen bubbles visualization. These turbulence manipulators are viewed as operators which suppress the level of the incoming turbulence and generate primarily through documented instabilities, new turbulence with scales characteristic of the device and its shear layers. For honeycombs, the suppression of the incoming turbulence appears to be mostly due to the inhibition of lateral components of the fluctuating velocity. For most devices, it is conjectured that part of the energy in the undesirable larger scales of motion drains away through the action of the Reynolds stresses of the smaller scale laminar and turbulent motions (including the instabilities). The performance of the manipulators is found to depend on the characteristics of the incoming turbulence including its frequency spectra, level, and spatial distribution and on the incoming mean flow profiles. The efficacy of devices generating large scale turbulences in smoothing out gross inhomogeneities in the mean velocity profiles is illustrated.

Author

**N73-11262\*** Advisory Group for Aerospace Research and Development, Paris (France)

**TECHNICAL EVALUATION REPORT ON THE AGARD SPECIALISTS' MEETING ON TURBULENT SHEAR FLOWS**

R. Michel. Jul. 1972. 22 p. refs. Conf. held at London, 13-15 Sep. 1971.

(AGARD AR 46). Avail. NTIS HC \$12.5

The main techniques applied to present turbulent flow

studies theoretical and experimental are defined. Attempts were also made to open avenues which may aid in such studies. Data cover general problems, phenomena and analytical techniques relating to the flows. Turbulent boundary layers, wakes, and jets are discussed. E H W

**N73-17248#** Advisory Group for Aerospace Research and Development, Paris (France)

#### **SUPERSONIC EJECTORS**

J. J. Ginoux, ed. (Von Karman Inst. for Fluid Dyn.) Nov. 1972 184 p. refs.  
(AGARDograph-183, AGARD-AG-183) Avail. NTIS HC \$11.25

A state of the art review on significant progress in the design of high performance supersonic ejectors is presented. Specific summaries cover design methods for ejector systems with second throat diffusers, ejector flow models, ejector designs for various applications, and ducted mixing and burning in coaxial streams. For individual titles, see N73-17249 through N73-17253.

**N73-17249** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany)

#### **ONE-DIMENSIONAL INVISCID ANALYSIS OF SUPERSONIC EJECTORS**

H. T. Uebelhack. In AGARD Supersonic Ejectors. Nov. 1972 p. 1-18. refs. (For availability see N73-17248 08-12)

The conservation equations are used to analyze the one dimensional flow patterns of supersonic ejectors. Two regimes of ejector operation, the supersonic and mixed flow, were studied. E H W

**N73-17260** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany)

#### **ANALYSIS AND DESIGN METHOD FOR EJECTOR SYSTEMS WITH SECOND THROAT DIFFUSERS**

H. T. Uebelhack. In AGARD Supersonic Ejectors. Nov. 1972 p. 17-30. refs. (For availability see N73-17248 08-12)

A flow model which permits the determination of starting and operating characteristics of a second throat ejector system is defined. Working equations are derived and design procedures described. The limits of application were discussed and compared with experiments. Author

**N73-17261** Illinois Univ., Urbana. Dept. of Mechanical and Industrial Engineering

#### **THE ANALYSIS OF SUPERSONIC EJECTOR SYSTEMS**

A. L. Addy. In AGARD Supersonic Ejectors. Nov. 1972 p. 31-101. refs. (For availability see N73-17248 08-12)

An analysis of the ejector flow model and its implementation is presented. Overall ejector performance characteristics were delineated on the bases of predominant flow mechanisms which occur within the various operating regimes. Data on operating characteristics, qualitative aspects of the ejector flow model, and various problem areas or projected problem areas are examined. Author

**N73-17262** ARO, Inc., Arnold Air Force Station, Tenn.

#### **EJECTOR DESIGN FOR A VARIETY OF APPLICATIONS**

Delbert Taylor. In AGARD Supersonic Ejectors. Nov. 1972 p. 103-183. refs. (For availability see N73-17248 08-12)  
(Contract F40600-69-C-0001)

Methods and techniques developed to improve the performance and applications of various ejector designs are examined. Data cover fixed value simple design and variable area/variable pressure ejectors. E H W

**N73-17263** ARO, Inc., Arnold Air Force Station, Tenn.

#### **ANALYSIS OF DUCTED MIXING AND BURNING OF COAXIAL STREAMS**

C. E. Peters. In AGARD Supersonic Ejectors. Nov. 1972 p. 165-187. refs. (For availability see N73-17248 08-12)  
(Contract F40600-69-C-0001)

An extensive theoretical and experimental investigation of ducted mixing was conducted. The basic objective was to develop an adequate engineering theory to describe the ducted mixing

process, including chemical reactions. Emphasis was placed on relatively long mixing systems in which the mixing layer may extend over most or all of the duct cross section at the exit plane. The duct pressure distribution will be strongly influenced by the thick mixing layers, and will be very different from the inviscid pressure distribution. Three distinct flow regimes are shown in the mixing flow. In the first regime, turbulent mixing occurs between the secondary flow and the core of inviscid primary flow. In the second regime, the inviscid core has dissipated, but a region of inviscid secondary flow exists near the duct wall. The third regime occurs after the mixing layer has spread to the wall, and the flow is entirely turbulent. Author

**N73-26279#** Advisory Group for Aerospace Research and Development, Paris (France). Fluid Dynamics Panel

#### **FLUID MOTION PROBLEMS IN WIND TUNNEL DESIGN**

Apr. 1973. 68 p. refs.  
(AGARD-R-602, AGARD-602) Avail. NTIS HC \$5.50

A series of research papers is presented relating to the design and operation of low speed and transonic wind tunnels with particular emphasis on the associated fluid motion problems. For individual titles, see N73-26280 through N73-26285.

**N73-26280** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany). Inst. fuer Angewandte Gasdynamik

#### **THE INFLUENCE OF THE FREE STREAM REYNOLDS NUMBER ON TRANSITION IN THE BOUNDARY LAYER ON AN INFINITE SWEEP WING**

E. H. Hirschel. In AGARD Fluid Motion Probl. in Wind Tunnel Design. Apr. 1973. 11 p. refs. (For availability see N73-26279 17-12)

The three-dimensional compressible laminar boundary layer on an infinite swept wing at different sweep angles is calculated and stability and transition criteria are applied to it for free-stream Reynolds numbers ranging from values possible nowadays in transonic wind tunnels to values typically for full scale flight. The distribution of the inviscid flow is taken from experiments on airfoils and exhibits for subsonic free stream Mach numbers supersonic regions terminating in shock waves at about 20 percent chord length. Results are given for four different wing sections. The techniques employed and their shortcomings are discussed. Author

**N73-26281** Royal Aircraft Establishment, Farnborough (England)

#### **SOME EXAMPLES OF THE APPLICATION OF METHODS FOR THE PREDICTION OF BOUNDARY-LAYER TRANSITION ON SHEARED WINGS**

D. A. Treadgold and J. A. Beasley. In AGARD Fluid Motion Probl. in Wind Tunnel Design. Apr. 1973. 1 p. refs. (For availability see N73-26279 17-12)

The laminar boundary layer was calculated for the leading-edge region of four selected airfoils for cases where the supercritical region is terminated by a shock wave at about 20% chord. The possibility of the boundary layer becoming turbulent before the shock wave is then considered according to four different criteria: leading-edge contamination, re-laminarisation, sweep instability, and Tollmien-Schlichting instability. Many simplifying assumptions have had to be made, since the purpose of the report is to demonstrate how the problem might be treated, rather than to present definitive results, and how the various mechanisms are seen in conjunction. It is concluded that much more needs to be known before predictions can be made confidently with any degree of precision. Author

**N73-26282** Royal Aircraft Establishment, Bedford (England)

#### **THE NEED FOR HIGH REYNOLDS NUMBER TRANSONIC TUNNELS**

C. R. Taylor. In AGARD Fluid Motion Probl. in Wind Tunnel Design. Apr. 1973. 13 p. refs. (For availability see N73-26279 17-12)

The present generation of transonic tunnels cannot simulate full scale flow at critical points of the flight envelope for many

current aircraft designs and there is an urgent need for new tunnels which would permit model tests to be made at much higher Reynolds numbers. New tunnels are proposed that would allow good simulations of aircraft shape to be made for a wide range of model tests; this limits the maximum tunnel total pressure to about 8 bars. A Reynolds number range which covers about half the full-scale range is advocated, demanding a working section area of about 25m squared. The tunnels would have low levels of free-stream turbulence and be capable of operation under conditions giving little heat transfer to the model. Running times of at least 10 sec are required. Author

**N73-26283** Royal Aircraft Establishment, Bedford (England)  
**ON THE INFLUENCE OF FREE-STREAM TURBULENCE ON A TURBULENT BOUNDARY LAYER, AS IT RELATES TO WIND TUNNEL TESTING AT SUBSONIC SPEEDS**

J. E. Green. In AGARD Fluid Motion Probl. in Wind Tunnel Design. Apr. 1973. 8 p. refs. (For availability see N73-26279 17-12)

Published experimental measurements are reviewed which show the turbulent boundary layer to be highly sensitive to turbulence in the free-stream. In zero pressure gradient a small increase in the streamwise rms velocity fluctuation is found to have the same effect on the shape of the velocity profile as a fractional increase in Reynolds number roughly sixty times as great. It is concluded that this effect needs to be taken into account in planning new wind tunnels for subsonic and transonic testing at high Reynolds number. Further experimental work is needed to clarify the importance of turbulence scale, the influence of pressure gradients and influence of radiated pressure (as opposed to convected vorticity) fluctuations. Author

**N73-26284** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Berlin (West Germany). Inst. fuer Turbulenzforschung  
**EFFECTS OF TURBULENCE AND NOISE ON WIND TUNNEL MEASUREMENTS AT TRANSONIC SPEEDS**

Adalbert Timme. In AGARD Fluid Motion Probl. in Wind Tunnel Design. Apr. 1973. 12 p. refs. (For availability see N73-26279 17-12)

Current knowledge is reviewed of the effects of flow unsteadiness on steady and dynamic measurements on models in wind tunnels at transonic speeds. It is found that in most cases the influence of the pressure or velocity fluctuations on flow patterns such as boundary layers with transition or separation, bubble flow or shock interaction is quantitatively known from experiments only for particular parameter combinations. No universal information about the turbulence effect in different situations is found, nor is there a general theory including all observed effects at conditions of interest. Only in the case of a turbulent boundary layer, at zero pressure gradient, a quantitative relation is known between the turbulence in the free stream and the boundary layer development. It is concluded, therefore, that new experimental work using advanced measuring techniques and a secured theoretical background is urgently needed for planning new wind tunnels for transonic testing at high Reynolds numbers. Author

**N73-26285** City Univ., London (England). Dept. of Aeronautics  
**DESIGN OF VENTILATED WALLS WITH SPECIAL EMPHASIS ON THE ASPECT OF NOISE GENERATION**

R. N. Cox and M. M. Freestone. In AGARD Fluid Motion Probl. in Wind Tunnel Design. Apr. 1973. 7 p. refs. (For availability see N73-26279 17-12)

The parameters influencing the design of ventilated wind tunnel walls in current use are reviewed, and noise generation by such walls is analyzed. By drawing an analogy between results from flows past two-dimensional cavities and the discrete frequency tones generated by perforated walls, some suggestions are made about the mechanisms responsible for the tones. Finally some possible methods of reducing unwanted noise from tunnel walls are discussed. Author

**N74-12042#** Imperial Coll. of Science and Technology, London (England). Dept. of Aeronautics  
**EFFECTS OF STREAMLINE CURVATURE ON TURBULENT FLOW**

P. Bradshaw. Paris GARD. Aug. 1973. 36 p. refs.  
(AGARD AG-169, AGARDograph-169). Avail. NTIS HC \$4.00

Streamline curvature in the plane of the mean shear produces surprisingly large changes in the turbulence structure of shear layers. These changes are usually an order of magnitude more important than normal pressure gradients and other explicit terms appearing in the mean-equations for curved flows. The effects on momentum and heat transfer in boundary layers are noticeable on typical wing sections and are very important on highly-cambered turbomachine blades; turbulence may be nearly eliminated on highly-convex surfaces, while on highly-concave surface momentum transfer by quasi-steady longitudinal vortices dominates the ordinary turbulence processes. The greatly enhanced mixing rates of swirling jets and the characteristic non-turbulent cores of trailing vortices are also consequences of the effects of streamline curvature on the turbulence structure. Author

**N74-18923#** Advisory Group for Aerospace Research and Development, Paris (France)  
**AERODYNAMIC INTERFERENCE INDUCED BY REACTION CONTROLS**

F. W. Spaid (McDonnell Douglas Corp., Huntington Beach, Calif.), L. A. Cassel (McDonnell Douglas Corp., Huntington Beach, Calif.) and R. E. Wilson, ed. (Naval Ordnance Lab., White Oak, Md.) Dec. 1973. 66 p. refs.  
(AGARDograph 173, AGARD AG-173). Avail. NTIS HC \$6.50

The literature pertaining to the interaction of a sonic or supersonic gaseous jet with a transverse external flow has been reviewed. The flowfields associated with these interactions are complex and knowledge of them is based largely on results of experiments. Numerous examples of data from flatplate experiments are presented. These include static pressure distribution, induced forces, flowfield survey, and flow visualization results. Analyses and correlation techniques for jet interaction flows are discussed. The region upstream of a jet in two-dimensional flow is similar to the flow upstream of a forward-facing step, and the flow associated with a jet from a circular nozzle in a flat plate resembles the flow past a blunt-nosed slender body. The single most important variable in determining the scale of these interactions is the ratio of jet momentum flux to the external flow dynamic pressure. When the external flow is subsonic the interaction is sensitive to external flow Mach number in the high subsonic Mach number range and to the ratio between jet and external flow velocity in the low Mach number range. Author

**N74-18924#** Advisory Group for Aerospace Research and Development, Paris (France)  
**DIGITAL TECHNIQUES IN TURBULENCE RESEARCH**

C. H. Gibson (Calif. Univ., La Jolla) and P. A. Libby, ed. (Calif. Univ.) Dec. 1973. 30 p. refs.  
(Contracts DAHCO4 72 C 0037, N00014 69 A 0200 6006, N00014 69 A 0200 6039, Grant NSF GA 22366).  
(AGARDograph 174, AGARD AG-174). Avail. NTIS HC \$4.50

Rapid advances in electronic information processing capabilities are providing powerful tools for turbulence research. Massive quantities of experimental information are necessary to characterize most turbulent flows given the primitive nature of theoretical understanding in the field. Analytical treatments are equally dependent on powerful high speed computers to cope with the most truncated form of the full turbulence problem. Author

**N74-22914#** Advisory Group for Aerospace Research and Development, Paris (France)  
**ADVANCES IN NUMERICAL FLUID DYNAMICS**

Feb. 1973. 146 p. refs.  
(AGARD LS 64; Avail. NTIS HC \$10.50)

Lectures are presented on the theory of numerical stability for linear and nonlinear hyperbolic and parabolic equations; fundamental aspects of integration procedures for nonlinear flow

problems including shocks by finite difference techniques, and fundamental concepts extensions, and generalizations of the finite element methods. For individual titles, see N74-22915 through N74-22921

**N74-22915** Uppsala Univ (Sweden). Dept of Computer Sciences

**BOUNDARY CONDITIONS FOR DIFFERENCE APPROXIMATION OF HYPERBOLIC DIFFERENTIAL EQUATIONS**

Heinz Otto Kreiss. In AGARD Advan in Numerical Fluid Dyn. Feb 1973 13 p refs (For availability see N74-22914 14-12)

Time dependent problems involving the processes of wave propagation and diffusion are dealt with. Solutions are given for calculating the boundary conditions and the difference approximation for hyperbolic differential equations in one space dimension. Separate solutions are shown for equations in more than one space dimension. D L G

**N74-22916** New York Univ., N.Y. Courant Inst. of Mathematical Studies

**NONLINEAR TIME DEPENDENT PROBLEMS IN FLUID DYNAMICS**

Samuel Z. Burstein. In AGARD Advan in Numerical Fluid Dyn. Feb 1973 20 p refs (For availability see N74-22914 14-12)

Three nonlinear problems in inviscid fluid dynamics are discussed. First we consider unforced finite amplitude vibrations of an undamped gas in a resonant cavity. The effect of amplitude on the vibrational frequency and wave shape is obtained by numerical integration of the complete nonlinear equations. The second problem is a nonlinear vibration problem with finite amplitude motion generated by a thermal forcing function. The forcing function is represented by a dilute spray of combustible fuel droplets in an oxidizing environment. In the last problem a computation in transonic flow is described. Author

**N74-22917** Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium)

**NUMERICAL INTEGRATION OF NAVIER-STOKES EQUATIONS**

H. J. Wirz and J. J. Smolderen. In AGARD Advan in Numerical Fluid Dyn. Feb 1973 13 p refs (For availability see N74-22914 14-12)

The Eulerian form of the Navier-Stokes equations is analyzed. A system of partial differential equations is obtained by expressing the conservation of mass, momentum, and energy in Eulerian coordinates. Several categories of boundary conditions are considered together with selected discretization methods. The requirements of convergence, consistency, and stability are dealt with as well as the aspects of accuracy and error bounds. D L G

**N74-22918** Technische Hochschule, Aachen (West Germany). Aerodynamisches Inst.

**NUMERICAL TREATMENT OF BOUNDARY LAYER PROBLEMS**

Egon Krause. In AGARD Advan in Numerical Fluid Dyn. Feb 1973 21 p refs (For availability see N74-22914 14-12)

Finite difference solutions for three-dimensional compressible laminar and incompressible turbulent boundary layers are discussed in detail. Several finite difference approximations are introduced with their respective stability limits as obtained from a linearized stability analysis and numerical calculation. The importance of the domain of dependence and the region of influence in three dimensional boundary layers is elucidated. The equations of motion are given in orthogonal and non-orthogonal coordinates. A discussion of surface and external flow oriented system of coordinates is included. For turbulent flows the eddy viscosity concept expressed through a mixing length is adopted for the description of the turbulent shear stresses. Three different approximations used in the recent literature for closure assumptions are compared with the transport equations for the components of the turbulent shearing stress in three dimensional flows as given by Bradshaw. The finite difference solution employed is an implicit one which does not require additional assumptions for the laminar sublayer. Second and fourth order

finite difference approximations enable acceptable computation times. Several results of sample calculations demonstrate the application of the method presented. Author

**N74-22919\*** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.

**SURVEY OF COMPUTATIONAL METHODS FOR THREE-DIMENSIONAL SUPERSONIC INVISCID FLOWS WITH SHOCKS**

R. W. McCormack and R. F. Warming. In AGARD Advan in Numerical Fluid Dyn. Feb 1973 20 p refs (For availability see N74-22914 14-12)

Hyperbolic systems of partial differential equations governing supersonic inviscid flows are discussed and analyzed. Finite-difference analogues for integrating these systems in the interior of fluid domains are described from two points of view: a differential form approach and an integral form approach. The algorithms presented are analyzed for stability and accuracy. The concept of time splitting is discussed and applied to these methods to achieve increased numerical efficiency. Techniques for treating conditions at the boundaries of the fluid domain and shock-wave discontinuities at surfaces within the domain are described. Author

**N74-22920** General Dynamics/Aeronautics, San Diego, Calif. Aerospace Div.

**A SURVEY OF COMPUTATIONAL METHODS FOR 2D AND 3D TRANSONIC FLOWS WITH SHOCKS**

H. Yoshihara. In AGARD Advan in Numerical Fluid Dyn. Feb 1973 35 p refs (For availability see N74-22914 14-12)

More recent developments in the calculation of steady transonic flows with shocks using the finite difference procedure are reviewed. For the planar case the unsteady procedure of Magnus-Yoshihara (exact) and the steady relaxation procedures of Murman-Cole (small disturbance), Garabedian-Korn (exact), and Jameson (exact) are described, stressing their viability particularly in terms of their ability to capture the embedded shocks properly. Numerous examples are presented. The review is then concluded by a description of several axial symmetric and three dimensional calculations carried out by NASA. Author

**N74-22921** Edinburgh Univ. (Scotland). Fluid Mechanics Unit

**NUMERICAL TREATMENT OF FLUID DYNAMICAL STABILITY PROBLEMS**

M. A. S. Ross. In AGARD Advan in Numerical Fluid Dyn. Feb 1973 24 p refs (For availability see N74-22914 14-12)

Various theories are reviewed which led up to the modified Rayleigh model for finite amplitude disturbances. The derivation and properties of the Orr-Sommerfeld equation are given along with applications for parallel flows bounded by solid walls, plane Poiseuille flow, and eigenfunction expansions. Published numerical methods and models for the development of turbulence are reviewed which include implicit methods, explicit methods, single function methods, parallel function methods, and the treatment of orthonormalization. D L G



## 13 GEOPHYSICS

Includes aeronomy, upper and lower atmosphere studies, oceanography, cartography, and geodesy. For related information see also 20 Meteorology, 29 Space Radiation, and 30 Space Sciences.

**N72-26346** Advisory Group for Aerospace Research and Development, Paris (France).

#### NOMENCLATURE OF TERRAIN COLOUR

I. C. Perry (Headquarters Army Aviation Centre, Middle Wallop, Engl.) Mar. 1972. 9 p. In ENGLISH, partly in FRENCH. Original contains color illustrations.

(AGARD-AG-159, AGARDograph-159) Avail. NTIS HC \$3.00

A simple method by which color may be universally identified is described and illustrated. The system is designed to function as a precise color identification scheme regardless of language translation or individual interpretation. Such a system is important in air-ground communications of aircraft and spacecraft and various other scientific endeavors where exactness is necessary. EHW

**N73-22350** Advisory Group for Aerospace Research and Development, Paris (France).

#### TOTAL ELECTRON CONTENT AND SCINTILLATION STUDIES OF THE IONOSPHERE

Jules Aarons, ed. (AFCL) Mar. 1973. 112 p. refs. (AGARD-AG-166, AGARDograph-166) Avail. NTIS HC \$7.75

The current state of knowledge of ionospheric total electron content is outlined with special emphasis placed on the North Atlantic region of the world due to NATO special requirements in this region. A numerical model of total electron content, valid over the European continent under certain conditions, is presented for systems engineering use for an average background total electron content correction. Typical values of total electron content are also given at various locations in the high, middle and equatorial latitudes. With more observational data being taken at many locations, an overall satisfactory picture of the world wide behavior of this important parameter is beginning to emerge. Author

**N74-14084** Advisory Group for Aerospace Research and Development, Paris (France).

#### NUMERICAL MODELS OF TOTAL ELECTRON CONTENT OVER EUROPE AND THE MEDITERRANEAN AND MULTI-STATION SCINTILLATION COMPARISONS

John A. Klobuchar (AFCL) and Jules Aarons (AFCL) Nov. 1973. 50 p. refs.

(AGARD AG-166A, AGARDograph-166A) Avail. NTIS HC \$4.50

A numerical model of the total electron content over Europe for sunspot minimum conditions was described, and a complete computer subroutine of the model is given. A TEC model value was obtained from the subroutine by specifying a season for one of the solar flux conditions contained in the model, a geographic latitude and a local time. Computer drawn isocontours of the original TEC data are shown, along with contours of the model output. For individual titles see N74-14085 through N74-14088.

**N74-14085** Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.

#### A NUMERICAL MODEL OF TEC OVER EUROPE FOR SUNSPOT MINIMUM CONDITIONS. 2

John A. Klobuchar. In AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi-Station Scintillation Comparisons. Nov. 1973. p. 2-15. refs. (For availability see N74-14084 05-13).

The complete model computer program is given, along with the coefficients necessary to determine TEC at any local time and latitude for each of nine different seasons. Also shown are

computer drawn isocontours, redrawn from the original data, and isocontours of the model output for each season. Author

**N74-14086** Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.

#### A NUMERICAL MODEL OF TEC OVER THE MEDITERRANEAN AREA

John A. Klobuchar. In AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi-Station Scintillation Comparisons. Nov. 1973. p. 10-22. (For availability see N74-14084 05-13).

A numerical computer program subroutine model of the total electron content (TEC) of the ionosphere over the Mediterranean area was constructed using mean seasonal data taken at Athens, Greece. Data for four seasons are available and a separate numerical model representation of the data was made for each season. The TEC of the ionosphere produces an additional delay in the travel time of radio waves over their free space velocity. Thus, a numerical representation of this additional time delay can be useful in planning and operating such systems. Author

**N74-14087** Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.

#### MULTI-STATION OBSERVATIONS. NOVEMBER 1971 - MARCH 1972

Jules Aarons. In AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi-Station Scintillation Comparisons. Nov. 1973. p. 24-29. refs. (For availability see N74-14084 05-13).

In November 1971, observations of the 136 MHz beacon of Intelsat 2F2 became possible in Western Europe. With the advent of multistation observations in Western Europe, a comparison of middle to low latitude data became feasible. Author

**N74-14088** Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.

#### THE EFFECT OF THE AUGUST 1972 MAGNETIC STORMS ON SCINTILLATION

Jules Aarons and Eileen Martin (Emmanuel Coll.). In AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi-Station Scintillation Comparisons. Nov. 1973. p. 30-44. ref. (For availability see N74-14084 05-13).

During the period 2 August to 10 August 1972, a series of flares on the sun triggered another series of geophysical events. The resulting magnetic storms were of great intensity with K sub p reaching values of 9, the maximum index twice. The effect on scintillations is of interest in two ways. First, it provides a worst case period so that a long time interval can be analyzed. Secondly, it provides a test for the descriptive model. Author

## 14 INSTRUMENTATION AND PHOTOGRAPHY

Includes design, installation, and testing of instrumentation systems, gyroscopes, measuring instruments and gages, recorders, transducers, aerial photography, and telescopes and cameras

**N71-20002#** Advisory Group for Aerospace Research and Development, Paris (France)

### A LITERATURE SURVEY ON THE GYROSCOPE AND ITS APPLICATIONS

Helmut Sorg (Stuttgart Univ.), Feb. 1971, 23 p, refs

AGARD 582 711 Avail NTIS

A consolidated listing is presented of all known unclassified texts which are readily available to scientists and engineers from commercial sources, documentation centers and public as well as corporate libraries. Each entry cites the author, publication year, title, documentation center source and a brief abstract of the work.

Author

**N71-36776#** Advisory Group for Aerospace Research and Development, Paris (France)

### RELIABILITY OF AVIONICS SYSTEMS

Jul. 1971, 191 p, refs. Mostly in ENGLISH, partly in FRENCH. Conf. held in Rome, 16-17 Sep. 1971 and London, 20-21 Sep. 1971. Sponsored by Avionics Panel and Exchange Programme of AGARD. Its Lecture Series No. 47.

AGARD-LS-47-711 Avail NTIS

#### CONTENTS

1. RELIABILITY AND SURVIVABILITY E. Keonjian (Grumman Aerospace Corp.)

2. TECHNIQUES OF SYSTEM RELIABILITY ESTIMATION, INCLUDING FAILURE EFFECT ANALYSIS (FAILURE CONSEQUENCE) W. T. Sumerlin (McDonnell Aircraft Corp., St. Louis, Mo.) 29 p, refs. (See N71-36777 23-15)

3. CORRELATION BETWEEN ESTIMATION TESTS AND SYSTEM OPERATING DATA M. M. Tall (RCA, Moorestown, N.J.) 9 p, refs. (See N71-36778 23-15)

4. EFFECTIVENESS OF RELIABILITY PROGRAM ELEMENTS W. T. Sumerlin (McDonnell Aircraft, St. Louis, Mo.) 9 p (See N71-36779 23-15)

5. COST EFFECTIVENESS OF BUILT-IN TEST PROVISIONS M. M. Tall (RCA, Moorestown, N.J.) 8 p, refs. (See N71-36780 23-15)

6. HIGH RELIABILITY DESIGN TECHNIQUES APPLIED TO THE LUNAR MODULE J. J. Bussolini (Grumman Aerospace Corp.) 34 p, refs. (See N71-36781 23-15)

7. TESTING THE RELIABILITY OF AVIONIC EQUIPMENT FOR SPACECRAFT APPLICATIONS G. Vollhardt (Siemens AG) 10 p. (See N71-36782 23-15)

8. METHODS OF SPECIFYING AND CONTROLLING DESIGN RELIABILITY J. J. Bussolini (Grumman Aerospace Corp.) 19 p, refs. (See N71-36783 23-15)

9. RELATIONSHIPS BETWEEN PROGRAM TEST AND USER SUPPORT COSTS M. M. Tall (RCA, Moorestown, N.J.) 9 p, refs. (See N71-36784 23-15)

9. RELATIONSHIPS BETWEEN PROGRAM TEST AND USER SUPPORT COSTS M. M. Tall (RCA, Moorestown, N.J.) 9 p, refs. (See N71-36785 23-15)

10. SYSTEM OPERATIONAL CONSIDERATIONS AND THEIR RELATIONSHIP TO THE TEST PROCESS W. T. Sumerlin (McDonnell Aircraft, St. Louis, Mo.) 8 p, refs. (See N71-36786 23-15)

11. TECHNIQUES OF ANALYZING ACCELERATION P. Blanquet (Centre Natl. d'Etudes des Telecommunications, Lannion, France) 8 p. (See N71-36787 23-23)

12. THE BENEFITS OF A TOTALLY INTEGRATED RELIABILITY TEST PROGRAM J. J. Bussolini (Grumman Aerospace Corp.) 21 p, refs. (See N71-36788 23-15)

13. OPERATIONAL CONSIDERATIONS AND SYSTEMS RELIABILITY B. E. Baker (Royal Air Force, High Wycombe, England) 7 p. (See N71-36789 23-15)

**N71-36777#** McDonnell Aircraft Corp., St. Louis, Mo. Engineering Reliability

### TECHNIQUES OF SYSTEM RELIABILITY ESTIMATION, INCLUDING FAILURE EFFECT ANALYSIS (FAILURE CONSEQUENCE)

W. T. Sumerlin. In AGARD Reliability of Avionics Systems. Jul. 1971, 29 p, refs. (See N71-36776 23-14)

Avail NTIS

The reliability estimation of an avionic system, which includes gross estimates, rapid estimates, and detailed estimates is discussed. Probability of attainment is then studied by selective reliability allocation among subsystems, followed by feasibility estimates based on experience, complexity, failure rate summations and/or other effective techniques. Constraints including allowable degradation, alternative mode operation, environment, operator effectiveness, and excellence of maintenance will permit improved estimates. Failure mode and effect analyses serves to guide conceptual design decisions so as to eliminate single point failures and identify areas for judicious application of redundancy, requirements for high reliability parts, special environmental control, and beneficial choice of operating profile.

Author

**N71-36778#** Radio Corp. of America, Moorestown, N.J. CORRELATION BETWEEN ESTIMATION TESTS AND SYSTEM OPERATING DATA

M. M. Tall. In AGARD Reliability of Avionics Systems. Jul. 1971, 9 p, refs. (See N71-36776 23-14)

Avail NTIS

The relationships between estimation tests and operational reliability are studied by regression analysis. The analysis includes equipment complexity and average mission length. Eleven equipment pieces were tested and results show that in several cases the reliability surpassed goals established for the tests. Results also indicate the tests may be used to refine the designs and remove defects introduced by parts, materials, and manufacture. Only avionic systems are used for the tests.

E. H. W.

**N71-36779#** McDonnell Aircraft Corp., St. Louis, Mo. Engineering Reliability

### EFFECTIVENESS OF RELIABILITY PROGRAM ELEMENTS

W. T. Sumerlin. In AGARD Reliability of Avionics Systems. Jul. 1971, 9 p. (See N71-36776 23-14)

Avail NTIS

An opinion is given of the probable relative importance of reliability program elements including reliability requirement evaluation and allocation, proof of attainment, parts control, design surveillance, failure analysis and design correction, and reliability progress measurement.

Author

**N71-36780#** Radio Corp. of America, Moorestown, N.J. COST EFFECTIVENESS OF BUILT-IN TEST PROVISIONS

M. M. Tall. In AGARD Reliability of Avionics Systems. Jul. 1971, 8 p, refs. (See N71-36776 23-14)

Avail NTIS

The feasibility of using built-in test provisions (BIT) as a means of improving operational effectiveness of aircraft is discussed. The primary purpose of BIT is to indicate to the user if the prime equipment is operating satisfactorily. It provides information upon which a decision to abort, modify or continue a mission may be based. Bit may also be applied to passive devices. In highly complex equipment BIT may indicate degrade

performance of portions of the equipment as well as catastrophic failure, and indicate the use of any alternate mode of operations. The cost effectiveness of BIT is also discussed. E.H.W.

**N71-36781#** Grumman Aerospace Corp., Bethpage, N.Y. Engineering Operations and Administration  
**HIGH RELIABILITY DESIGN TECHNIQUES APPLIED TO THE LUNAR MODULE** c15  
 J. J. Bussolini. In AGARD. Reliability of Avionics Systems. Jul. 1971. 34 p. refs (See N71-36776 23-14)  
 Avail. NTIS

A description is given of the significant design techniques applied to the lunar module to attain system reliability. The use of system work-arounds, functional redundancy, hi-rel parts screening, successive stage building block testing, vehicle testing, overstress testing, failure mode and effect analysis and many other techniques are described, illustrating their relative importance toward the success of the program. Author

**N71-36782#** Siemens-Schuckertwerke A. G., Munich (West Germany).  
**TESTING THE RELIABILITY OF AVIONIC EQUIPMENT FOR SPACECRAFT APPLICATIONS**  
 Guenter Vollhardt. In AGARD. Reliability of Avionics Systems. Jul. 1971. 10 p. (See N71-36776 23-14)  
 Avail. NTIS

To assess the stress limits and failure modes of spacecraft equipment, models were constructed and tested under various stresses and environmental conditions. The tests show failure to be caused by errors in mechanical or electrical design and drift of electrical and mechanical parts. Circuit analyses as well as mechanical and climatic tests were conducted. E.H.W.

**N71-36783#** Grumman Aerospace Corp., Bethpage, N.Y. Engineering Operations and Administration  
**METHODS OF SPECIFYING AND CONTROLLING DESIGN RELIABILITY**  
 J. J. Bussolini. In AGARD. Reliability of Avionics Systems. Jul. 1971. 19 p. refs (See N71-36776 23-14)  
 Avail. NTIS

Some examples of techniques used to accomplish early determination of system and equipment reliability requirements, the methods used to specify these requirements and the contractual techniques used to test and demonstrate compliance to specification requirements are examined. Incentive-penalty contracting for reliability is discussed including recommendations for relating these incentives and penalties to conventional and modified demonstration test techniques. Author

**N71-36784#** Radio Corp. of America, Moorestown, N.J.  
**RELATIONSHIPS BETWEEN PROGRAM TEST AND USER SUPPORT COSTS**  
 M. M. Tall. In AGARD. Reliability of Avionics Systems. Jul. 1971. 9 p. refs (See N71-36776 23-14)  
 Avail. NTIS

The significant factors that should be included in a cost ownership analysis of avionic equipments are discussed. The value of reliability improvement efforts, including AGREE type test programs, are assessed. Author

**N71-36785#** McDonnell Aircraft Corp., St. Louis, Mo. Engineering Reliability  
**SYSTEM OPERATIONAL CONSIDERATIONS AND THEIR RELATIONSHIP TO THE TEST PROCESS**  
 W. T. Sumerlin. In AGARD. Reliability of Avionics Systems. Jul. 1971. 8 p. refs (See N71-36776 23-14)  
 Avail. NTIS

Indicators for raising the reliability of a system hardware unit through burn-in tests, failure analysis and corrective design changes, are discussed. Mean time between failure (MTBF) is

used as an index of reliability to describe the operational requirements and to relate these requirements to tests and verification observations. The limitations and constraints of MTBF are also discussed. E.H.W.

**N71-36786#** Centre National d'Etudes des Telecommunications, Lannion (France)  
**TECHNIQUES OF ANALYZING ACCELERATION [LA TECHNIQUE DES ESSAIS ACCELERES]**  
 P. Blanquart. In AGARD. Reliability of Avionics Systems. Jul. 1971. 18 p. In FRENCH (See N71-36776 23-14)  
 Avail. NTIS

The reliability of electronic components after acceleration tests is discussed. The effects of vibration, humidity, and temperature on degradation are considered. Mathematical models and regression analysis are also discussed. E.H.W.

**N71-36787#** Grumman Aerospace Corp., Bethpage, N.Y. Engineering Operations and Administration  
**THE BENEFITS OF A TOTALLY INTEGRATED RELIABILITY TEST PROGRAM**  
 J. J. Bussolini. In AGARD. Reliability of Avionics Systems. Jul. 1971. 21 p. refs (See N71-36776 23-14)  
 Avail. NTIS

The benefits derived from a totally integrated test program in terms of cost, schedule, and resultant system reliability are discussed. Author

**N71-36788#** Royal Air Force, High Wycombe (England). Strike Command  
**OPERATIONAL CONSIDERATIONS AND SYSTEMS RELIABILITY**  
 B. E. Baker. In AGARD. Reliability of Avionics Systems. Jul. 1971. 7 p. (See N71-36776 23-14)  
 Avail. NTIS

The problem of deciding what reliability to specify and how to ensure that this reliability is achieved is discussed. An example is given of trade-offs between reliability and maintainability and performance parameters. The need for a formal reliability program is stressed and parts of this are discussed in detail. The value of reliability testing at the end of development is illustrated by a costed example. Author

**N71-36789#** Sandia Labs., Albuquerque, N. Mex.  
**HIGH INTENSITY DIRECT READING HEAT FLUX GAUGE**  
 H. C. Hardee and A. B. Donaldson. Apr. 1971. 9 p. refs. Sponsored by AEC.  
 (JC-DR-710194) Avail. NTIS

A high intensity direct reading heat flux gauge is described. The device can be used under a wide variety of field test conditions. The gauge is a quasi-steady state type and offers advantages over both the steady-state and the transient types. Because the signal output is directly proportional to the incident heat flux, data reduction errors are minimized. The device has the capability of a secondary, transient type measurement which provides a check on the primary measurement. A lab test was conducted in which the measurements obtained from the direct reading gauge were compared with measurements obtained from a calibrated steady-state gauge. Author (NSA)

**N72 19483#** Advisory Group for Aerospace Research and Development, Paris (France)  
**AVIONICS IN SPACECRAFT**  
 Ph. Hartl and John E. Twinn, eds. Sep. 1971. 349 p. refs. Proc. of the 220 Tech. Symp. of the Avionics Panel of AGARD. Rome. 31 May-4 Jun. 1971.  
 (AGARD CP 87/11) Avail. NTIS. HC \$t.00. MF \$0.95

The proceedings of a conference on avionics for spacecraft are presented. Subjects discussed are: (1) microelectronic equipment; (2) semiconductor devices; (3) attitude control systems; (4) remote sensors; (5) data processing equipment; (6) satellite communications; and (7) design of telemetry and telecommand

links for interplanetary space probes. A total of 31 papers was presented. For individual titles, see N72-19484 through N72-19514.

**N72-19484#** Air Force Systems Command, Wright-Patterson AFB Ohio. Air Force Avionics Lab.  
**MICROELECTRONICS FOR AEROSPACE SYSTEMS**  
H. V. Noble. In AGARD Avionics in Spacecraft. Sep 1971. 11 p. refs. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

The reasons for the entry of the USAF into microelectronics, some significant recent achievements, and predictions of microelectronic devices that will be available for aerospace systems for the 1975-1980 time period are presented. These predictions are based on the extension of advances made during the past few years plus estimates of results of current and future USAF programs. The following types of devices are covered: (1) digital and analog circuit devices for computer and data processing; (2) integrated microwave devices for both receivers and transmitters; (3) integrated circuit devices for high data rate transmission; (4) integrated circuit - antenna arrays; and (5) size reduction possibilities for computers based on use of advanced microcircuits. Author

**N72-19485#** Royal Aircraft Establishment, Farnborough (England). Space Dept.  
**HYBRID MICROCIRCUIT TECHNOLOGY IN THE BRITISH NATIONAL SPACE PROGRAM**  
H. D. Fisher. In AGARD Avionics in Spacecraft. Sep 1971. 15 p. refs. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

Experimental equipment to be flown on the X3 satellite in the British national space program is discussed. Arguments are presented in support of the use of hybrid microcircuits for very high quality, low volume production of electronic circuits. The current techniques are described and reasons for the choice of technologies are given. Process and component yields are examined. Author

**N72-19486#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).  
**CIRCUIT DESIGN FOR SPACECRAFTS WITH COMPLEMENTARY MOS INTEGRATED CIRCUITS**  
W. Schambeck. In AGARD Avionics in Spacecraft. Sep 1971. 10 p. refs. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

The application of complementary metal oxide semiconductor (CMOS) to spacecraft and commercial equipment is discussed. The use of CMOS for electronic clocks and portable instrumentation is described. The advantages resulting from low power dissipation and high circuit flexibility of CMOS circuits are examined. Some of the special considerations required in the design and operation of CMOS circuits are explained. Author

**N72-19487#** Communications Research Centre, Ottawa (Ontario).  
**AN IMPROVED APPROACH TO SELECTION OF HIGH RELIABILITY SEMICONDUCTOR COMPONENTS FOR SATELLITE PROGRAMS**  
A. R. Molozzi and R. F. Haythornthwaite. In AGARD Avionics in Spacecraft. Sep 1971. 7 p. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

Selection procedures to improve the quality of semiconductor devices used on the Alouette ISIS satellite program are discussed. The lack of reliability inherent in mass production of semiconductors and the impact on the design of satellites with five to ten year life span is described. The method for choosing semiconductor devices in order to obtain maximum component reliability is presented. The interrelation of circuit design and component selection is examined. Author

**N72-19488#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst fuer Satellitenelektronik.

**SOME NOVEL METHODS IN FAILURE ANALYSIS**  
E. Röss and G. Röss. In AGARD Avionics in Spacecraft. Sep 1971. 12 p. refs. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

Methods of conducting failure analysis of integrated circuits are discussed. The application of scanning electron microscopy for nondestructive tests in failure analysis is described. The modes in which the scanning electron microscope is used are presented. The types of failures which the scanning electron microscope is capable of detecting are described. Author

**N72-19489#** Montecatini Edison S. p. A., Milan (Italy).  
**INTEGRATED CHECK-OUT SYSTEM FOR SPACE LAUNCHERS AND AIRCRAFT SYSTEMS**  
Mauro Falleni. In AGARD Avionics in Spacecraft. Sep 1971. 16 p. refs. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

A completely integrated system capable of performing all the necessary operations for the check-out of space launchers of the 1970's generation and for aircraft systems is described. It is to be considered as a general purpose system. Any kind of real-time operation necessary for check-out operations and all the post-flight computation can be carried on without external aids. The general philosophy of its conception is such that certain attributes such as simplicity, modularity, minimum specialization allow for the widest possibility of efficiency and expansion possibly required for future, more elaborated check out procedures. A number of degraded levels of operation is allowed, the lowest of them being the manual operation level, in order to face different emergency situations. Special consideration has been given to the man-machine relationships and to the efficiency of maintenance and repair operations. Author

**N72-19490#** Montecatini Edison S.p.A., Milan (Italy).  
**CONSIDERATIONS ON A SUBSYSTEM FOR HANDLING COMMANDS AND STIMULI FOR AN INTEGRATED AND AUTOMATIC CHECK OUT OF SPACE LAUNCHERS**  
Mauro Falleni. In AGARD Avionics in Spacecraft. Sep 1971. 19 p. refs. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

A description of the stimuli and commands subsystem for the EUROPA 3 launch vehicle is presented. A description of the organization and functions of the system is given. Data transmission format and message structure are examined. The required circuits for handling the data flow are presented. Problems concerning the reliability of transmitting and executing a stimulus and/or a command are analyzed and partially solved. Other aspects of the interfaces between this subsystem and the other part of either the checkout system or the vehicle have been considered and solved in reasonable detail. Author

**N72-19491#** Philips Gloeilampenfabrieken, N. V., Geldrop (Netherlands).  
**ANS ATTITUDE CONTROL SUB-SYSTEMS**  
P. Van Otterloo. In AGARD Avionics in Spacecraft. Sep 1971. 10 p. (See N72-19483 10-14).  
Avail. NTIS HC \$6.00/MF \$0.95.

The attitude control subsystem and onboard computer for the ANS satellite are discussed. The ANS is an astronomical satellite for ultraviolet and X-ray measurements in space. A description of the satellite is presented. The requirements of the attitude control subsystem and the onboard computer are analyzed. The subsystems are described and their various modes of operation are explained. Author

**N72-19492#** Selenia S.p.A., Rome (Italy).  
**THREE AXIS R.F. ATTITUDE SENSOR OF A GEOSTATIONARY SATELLITE**  
Benito Palumbo. In AGARD Avionics in Spacecraft. Sep 1971.

17 p (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

A three axis radio sensor for satellite application is described. The system measures the attitude error of a three-axis stabilized geostationary satellite with respect to an earth station that transmits a RF beacon signal. A phase comparison two-dimensional system on-board the satellite is used for measuring the pitch and roll errors. The error around the yaw axis is obtained by comparing the orientation of the linear polarization of the on-board antennas with the polarization plane of the ground transmitted signal. The system and the design criteria of the components are presented. The pointing error sources are analysed and the accuracy of the system is evaluated. The required characteristics of the ground station are indicated with reference to the system operation. Author

**N72-19493#** Teldix Luftfahrt Ausruestungs G m b H, Heidelberg (West Germany)

**THE DRALLRAD: A FLYWHEEL FOR THE STABILIZATION OF SYNCHRONOUS SATELLITES**

Heinz Wehde / In AGARD Avionics in Spacecraft Sep 1971 7 p (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

The application and operation of flywheels for stabilization of synchronous satellites is discussed. Optimal relations between angular momentum, size, and weight are calculated. Rules for the use of ball bearings are established. The characteristics of a brushless, dc motor with optical commutation and permanent magnet excitation are described. The electrical and mechanical results obtained from various configurations are summarized. Author

**N72-19494#** Messerschmitt Boelkow Blohm G m b H, Munich (West Germany)

**ELECTRONICS OF A MASS SPECTROMETER**

V Gerber / In AGARD Avionics in Spacecraft Sep 1971 7 p (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

A quadrupole mass spectrometer consisting of an ion source, mass analyzer, multiplier, and associated electronics is described. The mass spectrometer will measure the absolute abundances of neutral atmospheric constituents and the relative composition of ambient ions. The various atmospheric parameters which can be determined by combined data from the mass spectrometer, impedance probe, retarding potential and neutral atmospheric temperature experiments are discussed. Author

**N72-19496#** Marconi Space and Defence Systems, Ltd., Farnley (England)

**METHODS OF IDENTIFICATION OF THE EARTH'S HORIZON AND EXAMPLES OF APPLICATION TO ATTITUDE DETERMINATION OF SPACECRAFT**

G G Fuller and M L Reynolds / In AGARD Avionics in Spacecraft Sep 1971 9 p refs (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

The attitude determination of earth orbiting satellites by sensing earth radiation is discussed. Various classes of missions and their relation to the different classes of earth sensors are examined. The earth's radiant field for visible and middle infrared wavelengths is described. Examples of several missions are presented and the sensors designed to fulfill the requirements of each mission are analyzed. Author

**N72-19498#** Officine Galileo S p A, Florence (Italy)

**SENSORS OF THE EARTH INFRARED HORIZON AND SOLAR SENSORS FOR SATELLITE ATTITUDE DETERMINATION**

R Baldassini Fontana / In AGARD Avionics in Spacecraft Sep 1971 10 p refs (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

An analysis is presented of a sensor system to be placed on board of a geostationary spinning satellite for the purpose of

determining the satellite attitude during the transfer and final orbit. The system consists of sensors of earth infrared horizon and sun sensors. The magnitudes to be observed and the type of information to be obtained in connection with the operational conditions, are analyzed. In addition, the results of the computations developed to optimize the parameters of the sensors and to establish the system accuracy, are described. Author

**N72-19497#** Officine Galileo S p A, Florence (Italy)

**SCANNING RADIOMETERS FOR METEOROLOGICAL SATELLITE**

V Rizzo / In AGARD Avionics in Spacecraft Sep 1971 11 p refs (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

The characteristics of imaging radiometers for mechanical scanning from a satellite platform in the infrared and visible spectra are discussed. A survey of the experimental objectives and their influence on the choice of spectral band to be used is presented. The trade-off between quality of picture and physical properties of the radiometer are examined. A typical instrument is shown in order to describe the nature of its operation. Author

**N72-19498#** Messerschmitt-Boelkow Blohm G m b H, Munich (West Germany)

**SATELLITE TELEVISION SYSTEM**

O Hofmann / In AGARD Avionics in Spacecraft Sep 1971 11 p refs (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

The operating principles of a satellite television recording system with no moving mechanical parts are presented. The television recording is performed by continuous line scanning with constantly open aperture. The scanning line is divided by several mirror strips and led to vidicons. By insertion of prisms the line sections can be dispersed spectrally. The essential characteristics of the system with emphasis on stereoscopic recording are described. Author

**N72-19499#** Royal Aircraft Establishment, Farnborough (England)

**AN EXPERIMENTAL CANOPUS STAR SENSOR**

P Haskell / In AGARD Avionics in Spacecraft Sep 1971 13 p refs (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

The Canopus star sensor and its application to the stabilization of the X4 technology satellite are discussed. The modes of operation performed by the spacecraft to check the parameters of the sensor are explained. Subsidiary experiments which may be conducted by the sensor during the mission are examined. Author

**N72-19500#** Lincoln Lab, Mass. Inst of Tech., Lexington

**THE USE OF VISIBLE LIGHT SENSORS IN SPINNING SATELLITE CONTROL SYSTEMS**

F Williams Scales, Jr / In AGARD Avionics in Spacecraft Sep 1971 8 p refs (See N72-19483 10-14)  
 Avail NTIS HC \$6 00/MF \$0 95

The application of visible light sensors in spinning satellite control systems launched during the Lincoln Experimental Satellite (LES) program is discussed. Earth location information use in either an intermittent or continuous sensing operation is described. It is concluded that an accuracy of one tenth of a degree should be realizable in circular, synchronous, near equatorial orbits. Author

**N72-19501#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)

**THE APPLICATION OF COMPLEMENTARY MOS CIRCUITS IN PCM SYSTEMS AS A QUALIFICATION TEST**

Manfred Moter / In AGARD Avionics in Spacecraft Sep 1971 6 p refs (See N72-19483 10-14)

Avail NTIS HC \$6 00/MF \$0 95

Two electronic devices, which are implemented with complementary MOS-circuits are described. One of these systems was part of an ESRO-payload, by the aid of which photographic and photometric measurements in the soft X-ray region had been carried out during a sounding-rocket flight. The aim of the experiment was an investigation of the sun corona. The electronic subsystem of the experiment had been developed for the measurement of the intensity of live emission-lines and for the conversion of these results into a PCM-signal. The second device is a quartz-clock with a PCM-output, which is installed in a recording current meter for an application in oceanography. It is specified for a very low power consumption and has to demonstrate the long-life qualities of complementary MOS-circuits for the undersea current meter is expected to have a lifetime of one year. Due to this long time and due to the necessity of low power consumption, the seaprobe is an ideal platform for a qualification test of components, which are provided for an application in spacecrafts. Though both devices have been developed as functional support for other experiments, they are technological experiments of our institute and part of our activities, to test and to introduce new components. Author

**N72-19502#** Royal Aircraft Establishment, Farnborough (England) Space Dept  
**DATA STORAGE FOR SMALL SCIENTIFIC SPACECRAFT**

A C Christmas and A H Spooner. In AGARD Avionics in Spacecraft Sep 1971 5 p (See N72-19483 10-14)  
Avail NTIS HC \$6 00/MF \$0 95

The reasons for on-board data storage are considered together with the type of storage necessary. This covers spacecraft status, continuously changing experiments, survey or totalising experiments and the organization of data into a form which is suitable for storage. These considerations together with telemetry and ground receiver requirements effectively specify the performance of a data storage system. Practical examples are given showing how the requirements have been met. The development, testing and orbital performance of an endless loop tape recorder, including the mechanical techniques used to meet the reliability, power and flutter requirements are described. Future needs are considered and compared with possible developments to give a forecast of the type of data storage which will be employed in later spacecraft. Author

**N72-19503#** Royal Aircraft Establishment, Farnborough (England)  
**A MODULAR SPACECRAFT PCM DATA CONDITIONING SYSTEM**

L Smith and K McDonald (Marconi Space and Defense Systems, Ltd.) In AGARD Avionics in Spacecraft Sep 1971 17 p refs (See N72-19483 10-14)  
Avail NTIS HC \$6 00/MF \$0 95

The PCM system developed for encoding and formatting data on board spacecraft is described. A set of standard modules has been designed which can be arranged in various ways to meet the many demands presented by the program. Within each module components are welded either to a nickel wire or a nickle-mylar interconnection matrix and then encapsulated to form slim cards. These are assembled and wire-wrapped to a back panel to produce functional units such as an encoder or decoder. Integrated circuits, purchased to in-house specifications which call for 100% inspection at all stages of manufacture and test, have been used wherever possible. The system accepts data in 3 forms: (1) digital in parallel or (2) serial form, and (3) analogue in the range plus or minus 5 volts. The analogue data is converted into 8 bit words prior to insertion into the main data stream. The maximum rate is 8,000 samples/sec which corresponds to a bit rate of 64 kHz. System feasibility was demonstrated using a prototype model and this has been developed and engineered into fully operational X3 system. Author

**N72-19504#** Standard Elektrik Lorenz A G, Stuttgart (West Germany)

**PROGRAMMABLE PCM TELEMETRY ENCODER FOR SPACE APPLICATIONS**

O Patst. In AGARD Avionics in Spacecraft Sep 1971 4 p (See N72-19483 10-14)

Avail NTIS HC \$6 00/MF \$0 95

The function of the programmable PCM Encoder in controlling the data handling necessary for transmission is discussed. The programmability has many advantages, since the specifications change from mission to mission. There are pre-wired and programmable functions. The generation of the control data will be achieved by a device within the encoder, very similar to a small computer. The program loading technique is compatible with nearly all command systems. The weight of an encoder is within the range of 1 to 3 kg, the power consumption varies from 1 to 4 watts depending on the bitrate. Author

**N72-19505#** Marconi Space and Defence Systems, Ltd., Portsmouth (England)

**USE OF COMPUTERS FOR REAL TIME SATELLITE CHECKOUT**

M A Skinner. In AGARD Avionics in Spacecraft Sep 1971 5 p (See N72-19483 10-14)

Avail NTIS HC \$6 00/MF \$0 95

The application of computers for automatic testing and data processing during the checkout of satellites is discussed. The rationale for selecting a digital computer for data processing and automatic control is explained. The requirement for the checkout to encompass all performance parameters and the amount of time required form the basis for computer use. The skills required to produce and use a computer controlled checkout system are examined. Author

**N72-19506#** IBM Italia, Rome

**AN APPROACH TO NATURAL LANGUAGE FOR COMMAND AND CONTROL SYSTEMS**

A Lanzara. In AGARD Avionics in Spacecraft Sep 1971 9 p refs (See N72-19483 10-14)

Avail NTIS HC \$6 00/MF \$0 95

The development of a user-oriented language for effective man machine communication is discussed. The feasibility of such a language for command and control purposes is examined. Different language models are analyzed and the basis for selection is explained. The influence of batch processing and on-line processing on the selection of the appropriate language is described. Author

**N72-19507#** Lincoln Lab, Mass Inst of Tech, Lexington  
**A VARIABLE COVERAGE SATELLITE ANTENNA SYSTEM**

A R Dion and L J Ricardi. In AGARD Avionics in Spacecraft Sep 1971 13 p refs (See N72-19483 10-14)

Avail NTIS HC \$6 00/MF \$0 95

A multi-beam antenna system and combiner switch capable of producing a variable coverage radiation pattern are described. The antenna consists of a waveguide lens illuminated by a 19-element feedhorn array. The combiner switch consists of a corporate arrangement of variable power dividers, the latter is made up of two phase shifters and two conventional hybrid power dividers. An earth-coverage radiation pattern with less than 2 dB ripple and an antenna gain of 20 dB is obtained by equally exciting all beams of the multi-beam antenna simultaneously. Excitation of a single feedhorn results in a narrow beam with an antenna gain of 30 dB and a near-in side lobe level less than minus 20 dB. The side lobe level can be reduced appreciably by appropriately exciting the adjacent feedhorns. The frequency bandwidth corresponding to 0.5 dB decrease in antenna gain is 10 percent. A technique for computing the radiation properties of the antenna is described. Author

**N72-19508#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)  
**DESIGN OF TELEMETRY AND TELECOMMAND LINKS FOR INTERPLANETARY SPACE PROBES**

E. Stolle. *In* AGARD Avionics in Spacecraft Sep 1971 16 p refs (See N72-19483 10-14)

Avail NTIS HC \$6.00 MF \$0.95

The concept of spacecraft earth telecommunication links is presented, and various system parameters with their influence on link performance are discussed. Of particular interest are: (1) power division between carrier and sidebands, (2) modulation indices, (3) demodulation/detection losses of RF receiver, (4) subcarrier demodulator, (5) bit synchronizer, (6) number of subcarriers, and parameter tolerances. The design criteria such as data rate, bit error rate, and spacecraft effective radiated power are discussed. An optimization method is given based on a criterion of minimum required total signal to noise ratio at the receiver. Examples from the link design for the HELIOS solar probe demonstrate the practicality of the approach. Author

**N72-19509#** Royal Aircraft Establishment, Farnborough (England)

**SOME ASPECTS OF MULTIPATH FADING IN AERONAUTICAL SATELLITE SYSTEMS**

M. J. Sidford. *In* AGARD Avionics in Spacecraft Sep 1971 15 p refs (See N72-19483 10-14)

Avail NTIS HC \$6.00 MF \$0.95

Information is presented which allows estimates to be made of the amplitudes and frequencies of the fades which occur in a satellite-to-aircraft radio link due to interference between the direct waves and the e reflected from the earth's surface. A wide range of conditions is covered involving reflecting surface properties, frequency and polarisation of the radio waves, aircraft antenna radiation pattern, and satellite elevation angle. Experimental evidence of multipath fading over sea and ice is included and recommendations are made for the aircraft aerial characteristics required to reduce this fading. Author

**N72-19510#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)  
**RANGING TRANSPONDERS FOR INTERPLANETARY SPACE PROBES**

H. Bassenberg and R. Stoiber. *In* AGARD Avionics in Spacecraft Sep 1971 12 p (See N72-19483 10-14)

Avail NTIS HC \$6.00 MF \$0.95

Different concepts such as direct amplification, use of doublers and triplers in solid state power amplifiers at 2.3 GHz with power output up to 20 W are discussed. The important characteristics values of a doubler concept are measured with a test set up of 1.15 GHz stripline amplifier using the power transistor 2N5921. Furthermore versions of cavity and stripline doublers using varactors MA 43000, MA 48 300, BXY 19 GB and stripline power dividers and combiners are discussed. Power chains connected in parallel make possible a 20 W amplifier at 2.3 GHz with a total efficiency of better than 30 percent. Author

**N72-19511#** Lincoln Lab, Mass Inst of Tech, Lexington  
**EFFICIENT X-BAND POWER GENERATION FOR SATELLITE COMMUNICATIONS**

D. M. Snyder. *In* AGARD Avionics in Spacecraft Sep 1971 9 p refs (See N72-19483 10-14)

Avail NTIS HC \$6.00 MF \$0.95

The efficient generation of solid state X-band power by utilizing the negative impedance characteristics of avalanche diodes in reflection amplifiers is discussed. Circuits with low level gains of 13 db with 500 mc bandwidth are described. Power outputs of one watt continuous wave with 5 db gain and 20 percent conversion efficiency in the same circuit are examined. Gain response curves for gallium arsenide diodes are included. Author

**N72-19512#** Royal Aircraft Establishment, Farnborough (England)

**MEASUREMENT OF ANTENNA RADIATION PATTERNS ON SPACECRAFT**

A. Stembidge. *In* AGARD Avionics in Spacecraft Sep 1971 11 p (See N72-19483 10-14)

Avail NTIS HC \$6.00 MF \$0.95

The measurement of antenna radiation patterns on spacecraft telemetry and telecommand antennas operating in the VHF (136 - 149 MHz) and UHF (435 - 470 MHz) frequency ranges is discussed. Measurements have been carried out on out door ranges by full scale and model techniques which are described. Facilities for making measurements have been limited to models weighing less than 100 lb. A new facility, now under construction, using improved techniques and capable of handling models up to 500 lb in weight is described. General techniques and methods of presenting results are explained and typical antenna radiation patterns are given. Some comments on merits of anechoic chamber and out door methods of measurement are made. Author

**N72-19513#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

**AUTOMATIC TRACKING OF Q-SWITCHED LASER RANGEFINDERS**

Roland Moreau. *In* AGARD Avionics in Spacecraft Sep 1971 12 p refs. *In* FRENCH, ENGLISH summary (See N72-19483 10-14)

Avail NTIS HC \$6.00 MF \$0.95

The automatic tracking of Q-switched laser rangefinders is discussed. Subjects presented are: (1) programmed tracking through ephemerides, (2) independent tracking using cartometric data, and (4) semiautomatic tracking. The acquisition period for each system is studied with emphasis on twenty four hour satellites. The effect of the pulse frequency is analyzed when there is a partially random displacement of the target. Author

**N72-19514#** Royal Aircraft Establishment, Farnborough (England)

**CHIRP MODULATION SYSTEM IN AERONAUTICAL SATELLITES**

G. W. Barnes, D. Hirst, and D. J. James. *In* AGARD Avionics in Spacecraft Sep 1971 10 p (See N72-19483 10-14)

Avail NTIS HC \$6.00 MF \$0.95

The advantages of chirp modulation for air ground digital communication by way of geostationary satellites are described. The effectiveness in reducing multipath reception and Doppler frequency shifts is discussed. The contribution of chirp modulation to reducing the limitations of marginal power budgets on satellite to aircraft links is examined. Flight tests of experimental systems are included. Author

**N72-25419#** Advisory Group for Aerospace Research and Development, Paris (France)

**GUIDANCE AND CONTROL DISPLAYS Technical Evaluation Report**

H. B. Lyon Jr. Mar 1972 9 p refs. Presented at 13th Symp of AGARD Guidance and Control Panel (AGARD AR 43). Avail NTIS HC \$3.00

The principal disciplines involved in the designing of displays for guidance and control and the evolution of the design process were discussed. An evaluation is presented from three viewpoints as an attempt to provide a better understanding of the total conference. These are: (1) general criteria, (2) criteria for specific applications, and (3) new technology. Author

**N72-25420#** Advisory Group for Aerospace Research and Development, Paris (France)

**FLIGHT TEST INSTRUMENTATION SERIES VOLUME 3 THE MEASUREMENT OF FUEL FLOW**

Paris, France Mar 1972 37 p refs  
 AGARDograph 150 Vol 3 AGARD AG 160 79131. Avail NTIS HC \$3.75

The main methods of fuel flow measurement are discussed and the prospective user is advised of the factors that should be considered in deciding which type of meter to use and what precautions to take in the installation. Details are given of the three main types of flowmeters in common use, namely turbine, orifice and angular momentum true mass. The theory of operation of each type of flowmeter is given together with details of accuracy, pressure drop, susceptibility to inlet and outlet conditions, form of output, and other key parameters likely to influence the choice of type of meter to be used. A quick reference summary is provided for the comparison of the performance of the three types of meter and various methods of calibrating flowmeters are discussed. A separate section is devoted to specialist flowmeters which are not in general use, but may have an application in flight test work. Particular emphasis is placed on solid state flowmeters which due to the need to obtain improved life and reliability, are the subject of much research work. Author

**N72-32467#** Advisory Group for Aerospace Research and Development, Paris (France)  
**FLIGHT RECORDING IN NATO COUNTRIES. SECOND EDITION**

Hollis G Zerkle, ed. Jul 1972. 75 p. refs.  
 (AGARD-AR-39) Avail. NTIS HC \$5.75

The characteristics and applications of flight recording instruments in NATO countries is discussed. The instruments and systems are presented according to manufacturer and the standard format contains the following data: (1) general information, (2) scope, (3) basic principles, (4) main characteristics, (5) history, (6) operational experience, and (7) installation. Flight recording projects leading to the development of new instruments are discussed, using similar format. A bibliography of pertinent reports and documents on various aspects of flight recorder application and performance is provided. Author

**N73-10450#** Advisory Group for Aerospace Research and Development, Paris (France)  
**FLIGHT TEST INSTRUMENTATION**  
 Sep 1972. 76 p. refs. Partly in ENGLISH and partly in FRENCH.  
 (AGARD LS 50) Avail. NTIS HC \$6.00

The impact of technological developments on improvements in the operating characteristics of flight test data systems is outlined. Special efforts were made to provide the non-engineer an outline of data acquisition, processing systems and capabilities, a look at mathematical techniques for extracting data from recorded information, and illustrate how these developments have influenced the design of flight test programs. For individual titles see N73-10451 through N73-10457.

**N73-10451** Boeing Co., Seattle, Wash. Commercial Airplane Group  
**FLIGHT TEST INSTRUMENTATION SYSTEMS OF THE 70'S**  
 Alex J Ferkovich. In AGARD Flight Test Instrumentation. Sep 1972. 11 p. (For availability see N73-10450 01-14)

The projected equipment, techniques, and procedures used in research flight test instrumentation systems are outlined. The impact of new technology on complex aircraft systems is discussed. E H W

**N73-10452** Advisory Group for Aerospace Research and Development, Paris (France)  
**AIRBORNE DATA ACQUISITION AND PROCESSING SYSTEMS**

Alain Klopstein. In AGARD Flight Test Instrumentation. Sep 1972. 12 p. (For availability see N73-10450 01-14)

The evolution of the in-flight measurement system concept from the mere compatibility of instruments to overall airborne data handling and processing is considered as well as its impact

on system structure. Illustrations are given of various types of equipment and systems and of their utilisation according to particular requirements. Author

**N73-10453** Royal Aeronautical Society, London, England  
**GROUND HANDLING TECHNIQUES AND SYSTEMS**  
 J M L Thomas. In AGARD Flight Test Instrumentation. Sep 1972. 4 p. (For availability see N73-10450 01-14)

The processing of data from large civil aircraft, particularly data from the Concorde's digital recordings, is discussed. Data cover digital magnetic tape for quasi-static parameters, FM magnetic tape for dynamic parameters, and film and paper tape for take off and landing measurements. E H W

**N73-10454** French Flight Test Center, Istres  
**DYNAMIC DATA PROCESSING SYSTEMS**  
 M B Pennacchioni. In AGARD Flight Test Instrumentation. Sep 1972. 18 p. (For availability see N73-10450 01-14)

An analysis was made of the systems used to measure in-flight take off runs, or landing data. Data are given for system flexibility, ease of pre- and post-processing, ease of communication between user and machine, bulk of system, and cost of using the system. Consideration is also given to measuring range, sensitivity, and accuracy of the system. E H W

**N73-10455** Princeton Univ., NJ, Dept. of Aerospace and Mechanical Sciences  
**THE ANALYSIS OF STEADY STATE AND RANDOM FLIGHT DATA**

E J Ourlin. In AGARD Flight Test Instrumentation. Sep 1972. 3 p. (For availability see N73-10450 01-14)

The functional dependence of test time of random and deterministic flight data analysis is investigated. The investigation covers test planning, instrumentation technology, and data analysis techniques. E H W

**N73-10456** Arizona State Univ., Tempe, Lab. for Measurement Systems Engineering  
**A UNIFIED APPROACH TO HANDLING NOISE IN MEASURING SYSTEMS**

Peter K Stein. In AGARD Flight Test Instrumentation. Sep 1972. 11 p. refs. (For availability see N73-10450 01-14)

A small portion of the new unified approach to the engineering of measuring systems is presented. The presentation and examples are selected to show the application of this approach to the determination, suppression, and documentation of noise levels in flight test measuring systems in which the initial measuring is of analog nature. A systematic methodology is developed for the determination and documentation of noise levels on any given test set up at any time, before, during or after a test, and without specific knowledge of the environmental factors which cause these noise levels. A strong plea is made for the recognition of measurement systems engineering as a discipline in its own right which can and must be incorporated into engineering curricula. The unified approach is offered as a starting point towards this end. The need for additional concept research in this field is identified and the hope is expressed that united efforts among various nations will result in the production of measurement-oriented or measurement-conscious engineers of all disciplines and at all levels. Author

**N73-10457** Messerschmitt Boelkow-Blohm G m b H, Munich (West Germany)  
**IMPACT OF NEW TECHNOLOGY AS ILLUSTRATED IN AN ADVANCED OPERATIONAL DATA SYSTEM**

Josef Herrmann. In AGARD Flight Test Instrumentation. Sep 1972. 11 p. (For availability see N73-10450 01-14)

The impact of new technology in flight test instrumentation equipment is given for a comprehensive and advanced airborne data acquisition system and ground data processing station. This advanced operational data system is used for flight testing of the high performance MRCA aircraft involving several aircraft prototypes for different tasks at different test sites. Author



**N73-11407#** Advisory Group for Aerospace Research and Development, Paris (France)

**V-STOL DISPLAYS FOR APPROACH AND LANDING**

Jul 1972 50 p refs

(AGARD-R 594) Avail NTIS HC \$4.50

The design and development of display systems were studied for developing all weather operational capability in terminal areas for V-STOL aircraft. Aspects of the study discussed include operational factors and ground environment, vehicle configuration, terminal area flight profiles, pilot factors, tradeoffs, guidance and control, and human engineering. The conclusions of the study are summarized, and the recommendations for future research and development are included. F.O.S.

**N73-18439#** Advisory Group for Aerospace Research and Development, Paris (France)

**DISPLAYS FOR APPROACH AND LANDING OF V-STOL AIRCRAFT**

Nov 1972 17 p

(AGARD-AR-51) Avail NTIS HC \$3.00 CSCL 018

An analysis of the display systems required for approach and landing of V-STOL aircraft was conducted. The various factors considered in the analysis are: (1) operational factors and ground environment, (2) guidance requirements, (3) relation between control and display sophistication, (4) information requirements, (5) human factors engineering, and (6) current display devices. Diagrams of proposed instrument panels and display devices are included. Author

**N73-20499#** Advisory Group for Aerospace Research and Development, Paris (France)

**AGARD FLIGHT TEST INSTRUMENTATION SERIES, VOLUME 2: IN FLIGHT TEMPERATURE MEASUREMENTS**

F. Trenkle, M. Reinhardt, W. D. Mace, ed. and A. Pool, ed.  
Feb 1973 171 p refs

(AGARD-AG-160 Vol 2, AGARDograph 160 Vol 2) Avail NTIS HC \$10.75

The field of temperature measurements in aircraft at Mach numbers up to 2.3 and altitudes up to 80,000 feet is reported. After a general discussion of the requirements of aircraft temperature measurements, and the available temperature sensing technology, the detailed techniques of using resistance probes and thermocouples, as well as the associated electrical leads, circuits, and indicators, are explained. A discussion of heat transfer processes, primarily between moving fluids and solids, includes terminology, the systematics of temperature measurements, and the concept of total temperature as the main operational parameter. One section deals with errors in temperature measurements as functions of various parameters in gases, liquids, and solids. Typical laboratory and in-flight calibration techniques for thermometry are described, followed by discussions of data handling, error analysis, and the limits of present methods. Author

**N74-14118#** Advisory Group for Aerospace Research and Development, Paris (France)

**AGARD FLIGHT TEST INSTRUMENTATION SERIES, VOLUME 4: THE MEASUREMENT OF ENGINE ROTATION SPEED**

M. Vedrunes, W. D. Mace, ed. and A. Pool, ed. Oct 1973 32 p refs 4 Vol

(AGARD AG 160 Vol 4) Avail NTIS HC \$3.75

The techniques and systems used to measure engine rotation speeds are analyzed. Chronotachometers, tachogenerators, and magnetic sensors are discussed along with the design of airborne measuring systems. The advantages and disadvantages of each type are presented. The telemetry systems and calibration procedures are described. For Vol 2 see N73-2049 for Vol 3 see N72-25420. F.O.S.

## 15 MACHINE ELEMENTS AND PROCESSES

Includes bearings, seals, pumps, and other mechanical equipment; lubrication, friction, and wear; manufacturing processes and quality control; reliability; drafting; and materials fabrication, handling, and inspection.

**N72-19541#** Advisory Group for Aerospace Research and Development, Paris (France) Structures and Materials Panel  
**APPLICATION OF NON-DESTRUCTIVE INSPECTION METHODS TO AIRCRAFT STRUCTURES**  
P. Gallinaro and R. B. Oliver, Oct 1971, 34 p, refs  
(AGARD-R-587-71) Avail NTIS

Nondestructive test methods are defined and their application for inspection of aircraft structures is evaluated, based on the results of an aircraft industry survey. For individual titles, see N72-19542 through N72-19543.

**N72-19542#** Advisory Group for Aerospace Research and Development, Paris (France)  
**NONDESTRUCTIVE INSPECTION OF STRUCTURES**  
P. Gallinaro, *In its Appl of Nondestructive Inspection Methods to Aircraft Struct*, Oct 1971, p 3-14, refs (See N72-19541 10-15)  
Avail NTIS

Current methods of inspection are reviewed and their application is defined for three major areas: (1) inspection of adhesive bonded structures; (2) inspection of welded joints; and (3) inspection of riveted or bolted joints. D L G

**N72-19543#** Advisory Group for Aerospace Research and Development, Paris (France)  
**SURVEY ON THE APPLICATION OF NONDESTRUCTIVE INSPECTION METHODS TO COMMERCIAL AIRCRAFT, 1968 TO 1970**  
Robert B. Oliver, *In its Appl on Nondestructive Inspection Methods to Aircraft Struct*, Oct 1971, p 15-20 (See N72-19541 10-15)  
Avail NTIS

Data related to the application of nondestructive inspection methods were acquired from commercial airline overhaul bases, airframe manufacturers, research laboratories, and equipment manufacturers. The project was aimed at: (1) evaluating the current experiences in nondestructive inspection; (2) isolating the best nondestructive inspection procedures; and (3) making recommendations to improve the accuracy of the methods and to stimulate development of improved methods. The results of the project are presented in the form of a state of the art review. D L G

## 16 MASERS

Includes applications of masers and lasers. For basic research see 26 Physics, Solid-State

**N72-25493#** Advisory Group for Aerospace Research and Development, Paris (France)  
**LASER TECHNOLOGY IN AERODYNAMIC MEASUREMENTS** AGARD Lecture Series  
 R C Pankhurst, ed. Mar 1972. 249 p. refs. Presented at Rhode-Saint-Genese, Belgium, 14-18 Jun 1971, sponsored by AGARD. Fluid Dyn. Panel and von Karman Inst. for Fluid Dyn. (AGARD-LS-49). Avail. NTIS HC \$14.50

The proceedings of a conference on the use of lasers for measuring aerodynamic applications are presented. The subjects discussed are: (1) principles of holography; (2) mathematical methods in coherent optical systems analysis; (3) laser beams for aerodynamic flow field analysis; (4) laser Doppler velocimeters for wind tunnel applications; (5) laser applications for high speed photography; and (6) laser metrology. For individual titles, see N72-25494 through N72-25506

**N72-25494#** Tennessee Univ., Tullahoma. Space Inst.  
**AN INTRODUCTION TO THE LASER**  
 T H Gee. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 5 p. refs. (See N72-25493 16-16)  
 Avail. NTIS HC \$14.50

The basic principles of laser operation are discussed. The properties which characterize its performance as a source of quasi-monochromatic radiation in and near the visible range of the electromagnetic spectrum are described. The various materials which are used for lasers and the construction of the resonant cavity are explained. The three classes of energy levels are discussed and schematic representations are included. Author

**N72-25495#** Tennessee Univ., Tullahoma. Space Inst.  
**PRINCIPLES OF HOLOGRAPHY**  
 T H Gee. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 13 p. ref. (See N72-25493 16-16)  
 Avail. NTIS HC \$14.50

The principles of holography are discussed. Holography is the process of recording complex wavefronts of light scattered by a scene (object) and subsequent release of the recorded wavefronts to reconstruct the original scene. The reconstruction contains all of the geometrical characteristics of the original scene which one would observe by viewing the scene through a window whose dimensions are those of the recording medium. The basis of the recording process is interferometry. A complex wavefront is made to interfere with a known reference wave and the result recorded by a square law detector. Author

**N72-25496#** Tennessee Univ., Tullahoma. Space Inst.  
**MATHEMATICAL METHODS IN COHERENT OPTICAL SYSTEMS ANALYSIS. FIRST ORDER ANALYSIS OF A HOLOGRAPHIC SCHLIEREN SYSTEM**  
 T H Gee. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 7 p. refs. (See N72-25493 16-16)  
 Avail. NTIS HC \$14.50

The mathematical methods employed in the analysis of coherent optical systems are demonstrated by an illustrative example. This example involves an optical configuration which may be employed as a holographic Schlieren system and illustrates the Fourier transform properties of positive thin lens hologram formation and reconstruction, magnification and various approximations which are normally made in a first order analysis. The coherent optical configuration is presented. Author

**N72-25497#** Queen Univ., Belfast (Northern Ireland)  
**EFFECTS OF COHERENCE ON FLOW VISUALIZATION METHODS**

L H Tanner. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 2 p. (See N72-25493 16-16)  
 Avail. NTIS HC \$14.50

The application of coherent light to flow visualization procedures is discussed. Diagrams illustrating the differences between thermal light sources and coherent light sources are presented. The advantages of laser light over conventional light are described and mathematical models are included to support the theoretical considerations. Author

**N72-25498#** ARO, Inc., Arnold Air Force Station, Tenn.  
**AERODYNAMIC HOLOGRAPHY**  
 J D Frolinger. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 18 p. refs. (See N72-25493 16-16)  
 Avail. NTIS HC \$14.50

Applications of holography in aerodynamics and related mechanics are discussed. Included are holographic generalized flow visualization, interferometry, and three dimensional recording. The high resolution analysis of dynamic nearly transparent three dimensional field of light scattering elements is described. Specific applications of particulate matter in explosions, plasmas, rocket and engine exhausts, and in wind tunnel and similar research facilities are examined. It is concluded that holography provides data not obtainable by other means and has economic and technical advantages over conventional means of data acquisition. Author

**N72-25499#** Michigan Univ., Ann Arbor. Inst. of Science and Technology  
**EXPERIMENTAL HOLOGRAPHY**  
 J Upatnieks. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 8 p. refs. (See N72-25493 16-16)  
 Avail. NTIS HC \$14.50

The formation of a hologram and the recording of the interference pattern between a reference beam and the light waves reflected from an object or scene are discussed. Holography is interferometry and the technology of this subject applies to holography as well. The factors affecting the formation of the hologram, the quality and characteristics of reconstructed images, and various optical systems for constructing holograms are considered. Author

**N72-25500#** Michigan Univ., Ann Arbor. Radar and Optics Lab.  
**CHARACTERISTICS OF DIELECTRIC HOLOGRAMS**  
 J Upatnieks and C D Leonard. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 9 p. refs. (See N72-25493 16-16)  
 (Contracts F33615-67-C-1814, F33615-68-C-1310)  
 Avail. NTIS HC \$14.50

The diffraction efficiency and signal-to-noise ratio for two-dimensional and volume diffuse-signal-beam holograms are calculated and experimentally determined. Calculations are based on the statistical properties of the signal beam, and exact integrals rather than series approximations are used. High signal-to-noise ratio and high diffraction efficiency are possible, with the peak calculated diffraction efficiency being 22% for two-dimensional and 64% for volume holograms. The experimentally achieved efficiencies were 12% for two-dimensional and 36% for volume holograms. Author

**N72-25501#** TRW Systems Group, Redondo Beach, Calif.  
**PULSED LASER HOLOGRAPHY**  
 R F Wuerker and L O Hellinger. In AGARD Laser Technol. in Aerodyn. Meas. Mar 1972. 14 p. refs. Previously published in The Eng. Uses of Holography by E R Robertson and J M Harvey. Cambridge Univ. Press 1970. (See N72-25493 16-16)  
 (Contracts NASw 1572, JPL-952023, F04611-67-C-0105, F33615-68-C-1119)  
 (NASA CR-126767). Avail. NTIS HC \$3.00 CSCL 20E

The development of optical systems used in holography which compensate for the limited spatial-temporal coherence of Q-switched ruby laser illuminators is discussed. The employment of the equipment to record projectiles in flight, aerodynamic wakes, and electric discharge plasmas is described. Diagrams and drawings are supplied to show the construction and operation of the system. P.N.F.

**N72-25502#** TRW Systems Group, Redondo Beach, Calif  
**RUBY LASER HOLOGRAPHY**

R. F. Wuerker and L. O. Hellinger. In AGARD Laser Technol in Aerodyn Meas. Mar 1972. 13 p. refs. Repr. from SPIE J., v. 9, 1971, p. 122-130, also from Proc. of the Conf. in Anaheim, Calif., 14-17 Sep. 1971. (See N72-25493 16-16). (Contract F33615-69 C 1630). Avail. NTIS HC \$14.50.

The solid state ruby laser for recording of holograms without either the granite tables or vibration isolation equipment needed with gas lasers is discussed. The ruby laser is unique in that it can be made to emit several joules of light in a tenth of a microsecond. In their more conventional form, these lasers are not particularly coherent, due to the width of the ruby R sub 1 lasing transition. Temporal coherence can be as low as one centimeter. The development of holographic configurations which compensated for the limited spatial and temporal coherence of ruby lasers is considered. These were used to record transmission holograms of combustion in rocket engines, aerodynamic flow patterns and particulate matter in coal furnaces. Author

**N72-25503#** Institut Franco Allemand de Recherches, St. Louis (France)  
**LASER BEAM PROBING FOR AERODYNAMIC FLOW FIELD ANALYSIS**

Bernard Koch. In AGARD Laser Technol in Aerodyn Meas. Mar 1972. 20 p. refs. (See N72-25493 16-16). Avail. NTIS HC \$14.50.

The application of laser beams for the measurement of aerodynamic flow fields at supersonic and hypersonic speeds is discussed. The subjects presented are: (1) basic methods of optoelectronic flow field probing; (2) single beam techniques; (3) small diameter beam method for supersonic free jet investigation; (4) twin or multiple beam techniques; (5) crossing beam method; (6) multiple beam interferometry; and (7) Doppler difference method. Author

**N72-25504#** Max-Planck-Institut fuer Plasmaphysik, Munich (West Germany)  
**LASER A LIGHT SOURCE FOR HIGH SPEED PHOTOGRAPHY**

K. Buechl. In AGARD Laser Technol in Aerodyn Meas. Mar 1972. 22 p. refs. (See N72-25493 16-16). Avail. NTIS HC \$14.50.

The application of lasers as an indirect light source for high speed photography is discussed. Examples of such applications are laser produced plasmas for vacuum ultraviolet light sources or electron sources, ultrafast trigger and calibration of image converter cameras, and a light gated Kerr cell. The characteristics of lasers for photographic use are described and mathematical models are included to support the theoretical considerations. Author

**N72-25505#** ARO, Inc., Arnold Air Force Station, Tenn.  
**LASER METROLOGY**

A. E. Lennert, D. B. Brayton, F. L. Crossway, W. H. Goethert, and H. T. Kolb. In AGARD Laser Technol in Aerodyn Meas. Mar 1972. 98 p. refs. (See N72-25493 16-16). Avail. NTIS HC \$14.50.

The development of a laser Doppler velocity instrument to measure velocities of flowing fluids is discussed. The electro-optical instruments are being developed for enhancing the measuring capabilities in wind tunnels. The basic design parameters of the input aligned optics LDV system and in

particular, the development of a self-aligning system to alleviate the basic problems inherent with previously conceived systems, are described. The design and the progress made on a direct readout system to determine three orthogonal components of velocity directly are presented. A number of significant proof-of-principle experiments covering a wide variety of flows, both liquid and gaseous, are discussed. The results of a number of wind tunnel calibrations verifying the superior performance of the LDV for not only velocity determination but also to perform boundary layer measurements are also included. Author

**N72-25506#** ARO, Inc., Arnold Air Force Station, Tenn.  
**Experimental Research**

**APPLICATION OF DUAL SCATTER LASER DOPPLER VELOCIMETERS FOR WIND TUNNEL MEASUREMENTS**

A. E. Lennert, F. H. Smith, and R. L. Parker. In AGARD Laser Technol in Aerodyn Meas. Mar 1972. 16 p. refs. (See N72-25493 16-16). Avail. NTIS HC \$14.50.

A dual scatter laser Doppler velocimeter (LDV), used in both forward and back scatter modes, and a direct data readout system are described. The characteristics of the dual scatter system are such that no seeding of flow is required to effect the measurements. With minor modifications and improvements, the dual scatter LDV system, both forward and back scatter, supplants conventional measuring devices. Descriptions of the application of the instrument to actual wind tunnel measurements including calibration of a one-foot transonic wind tunnel, flow field measurements of a simulated helicopter downwash, and flow field mapping across a high lift wing section are included. Author

## 17 MATERIALS, METALLIC

Includes cermets corrosion, physical and mechanical properties of materials, metallurgy, and applications as structural materials. For basic research see 06 Chemistry. For related information see also 18 Materials Nonmetallic and 32 Structural Mechanics.

**N72-20491#** Advisory Group for Aerospace Research and Development, Paris (France).

### **NATO NATIONAL REPORTS ON HIGH TEMPERATURE CORROSION OF AEROSPACE ALLOYS**

R. I. Jaffee, ed. (Battelle Mem. Inst., Columbus, Ohio) Feb. 1972. 36 p.

(AGARD-R-591) Avail. NTIS

A presentation, in a series of brief statements, on much of the research and development work in progress and some that is planned, in nine (9) NATO countries, on high temperature corrosion of aerospace alloys is given. Author

**N73-23597#** Advisory Group for Aerospace Research and Development, Paris (France).

### **HIGH TEMPERATURE CORROSION OF AEROSPACE ALLOYS**

J. Stringer, ed. (Liverpool Univ.), R. I. Jaffee, ed. (Battelle Columbus Labs., Ohio), and T. F. Kearns, ed. (Naval Air Systems Command) Mar. 1973. 338 p. refs. In ENGLISH and partly in FRENCH. Conf. held at Lyngby, Denmark, 10-12 Apr. 1972. (AGARD-CP-120) Avail. NTIS HC \$19.00

Results are presented of conference discussions on the effects of high temperature corrosion and oxidation of alloys for future applications in aerospace vehicles. For individual titles, see N73-23598 through N73-23618.

**N73-23598** Max-Planck-Institut fuer Physikalische Chemie, Göttingen (West Germany).

### **GENERAL ASPECTS OF HIGH TEMPERATURE CORROSION OF STRUCTURAL MATERIALS**

Carl Wagner. In AGARD High Temp. Corrosion of Aerospace Alloys. Mar. 1973. p. 3-7. refs. (For availability see N73-23597 14-17).

An oxidation scale for high temperature corrosion of structural materials is examined and its requirements established. Scale requirements include: (1) low concentration of ionic defects effective in metal ion transport; (2) negligible vaporization of oxides in the scale; and (3) freedom from pores or cracks and firm adherence to underlying alloy even during rapid temperature changes. Author

**N73-23599** National Gas Turbine Establishment, Pyestock (England).

### **THE ENVIRONMENT ENCOUNTERED BY HIGH TEMPERATURE COMPONENTS OF THE AIRCRAFT GAS TURBINE**

J. E. Restall. In AGARD High Temp. Corrosion of Aerospace Alloys. Mar. 1973. p. 11-30. refs. (For availability see N73-23597 14-17).

A brief examination is made of the factors governing the behavior of hot components: combustion chamber, nozzle guide vanes, and turbine rotor blades, in aero engines in the absence of a hot salt corrosion environment. The effects on components in engine trails of controlled additions of salt made to the intake air and fuel are discussed. Author

**N73-23600** Societe Nationale d'Etudes et de Construction de Moteurs Aeronautiques, Corbeil (France).

### **MATERIALS CURRENTLY EMPLOYED IN HIGH TEMPERATURE COMPONENTS OF THE AIRCRAFT GAS TURBINE**

M. Brunetaud. In AGARD High Temp. Corrosion of Aerospace Alloys. Mar. 1973. p. 31-42. In FRENCH, ENGLISH summary. (For availability see N73-23597 14-17).

General aspects of the high temperature components of the gas turbine are briefly reviewed, along with mechanical and chemical properties required of materials. Commercial nickel and cobalt base superalloys are reviewed in terms of their 1000-hour rupture strengths, together with some experimental alloys currently being developed. This last group includes powder metallurgy alloys, directionally solidified alloys, and alloys based on the refractory metals. Hot corrosion resistant superalloys contain high chromium contents, at the expense of high temperature strength. Designers are currently attempting to develop an intermediate group of high strength alloys with acceptable corrosion resistance complemented by aluminum-based diffusion coatings. Author

**N73-23601#** National Aeronautics and Space Administration, Washington, D.C.

### **THE ENVIRONMENT AND MATERIALS FOR GLIDE REENTRY VEHICLES**

G. C. Deutsch. In AGARD High Temp. Corrosion of Aerospace Alloys. Mar. 1973. p. 43-59. (For availability see N73-23597 14-17).

CSCD 22C

The environmental conditions to which a large glide reentry vehicle such as the space shuttle is subjected is discussed. A comparison is made with the state of the art for materials and structures to meet this environmental threat. The options that are available are stressed as are the areas where additional research and development is required. Author

### **N73-23602** Belgian Center for Corrosion Study, Brussels. **WHAT ARE THE ADVANTAGES AND LIMITATIONS IN THE USE OF EQUILIBRIUM THERMODYNAMICS FOR THE TREATMENT OF COMPLEX HIGH TEMPERATURE CORROSION REACTIONS?**

M. Pourbaix. In AGARD High Temp. Corrosion of Aerospace Alloys. Mar. 1973. p. 63-78. refs. (For availability see N73-23597 14-17).

The conditions of thermodynamic stability of every species which may exist in a given system, whatever the complexity, may be represented by means of suitable diagrams. These enable one to predict the general conditions (temperature, pressure, composition of the gaseous phase) where a given solid or liquid compound may be stable, metastable or unstable. Three types of diagram are illustrated in which the ordinates and abscissae are respectively  $\log P_{\text{sub O}_2}$  and  $1/T$ ,  $RT \ln P_{\text{sub O}_2}$  and  $T$ , and  $E$  and  $T$ . The relative values of these methods of representation are discussed and their applications to the studies of corrosion problems is outlined. Author

**N73-23603** Orleans Univ. (France).

### **RELATIONS BETWEEN INITIAL METALLIC SUBSTRATE AND FIRST STAGE OF THE REACTION AND FORMATION OF OXIDE LAYERS. [RELATIONS ENTRE L'ETAT INITIAL D'UN SUBSTRAT METALLIQUE, LES PREMIERES ETAPES DE LA REACTION ET LA FORMATION DES COUCHES D'OXYDE]**

J. Bardolle. In AGARD High Temp. Corrosion of Aerospace Alloys. Mar. 1973. p. 79-95. refs. In FRENCH, ENGLISH summary. (For availability see N73-23597 14-17).

The influence of surface preparation on the state of crystallization near the metal surface is summarized, and it is noted that the damaged layer introduced by mechanical polishing can be removed by electropolishing. Several examples are quoted on the effect of surface preparation on the growth of thin oxide films. Minor impurities in the metal or at the oxidizing surface may have a marked effect on the oxidation rate, and in particular on the scale, metal adhesion, impurities may also change the ductility of the oxide. The mechanisms of the early stages of an oxidation reaction are briefly summarized and ways in which the progress of these may affect the later oxidation are discussed. Author

### **N73-23604** Central Inst. for Industrial Research, Oslo (Norway). **TRANSPORT PROCESSES IN SCALES IN HIGH TEMPERATURE CORROSION**

P. Kolstad. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 97-116. refs (For availability see N73-23597 14-17)

Scales are characterized as (1) porous, (2) dense and compact, or (3) continuous, but containing appreciable porosity or voids. Porous scales are not normally associated with protective oxidation behavior, and are not discussed. Dense and compact scales are very uncommon in practice, but can usefully be discussed as a limiting ideal case. The kinetics of the growth of a scale in which the rate limiting process is the transport of reactants and electrons through the scale is very briefly summarized. The transport properties of a number of oxides are reviewed to determine which is the most desirable scale to be formed on an oxidation-resistant alloy. Although it is clear that the formation of a Cr<sub>2</sub>O<sub>3</sub> layer will result in a reduction in the oxidation rate of Ni and Co, there is no doubt that the most protective scale layer would be Al<sub>2</sub>O<sub>3</sub>, and this is consistent with observation. There are many possible effects of impurities on diffusion rates in oxides, and the example of lower valent cations dissolving in an oxygen deficient MO<sub>2</sub> oxide is briefly discussed. The influence of porosity on the growth of a substantially compact scale is discussed, and it was concluded that on balance it is undesirable, often enhancing the oxidation rate and weakening the scale. Selective and internal oxidation are clearly of great importance, and the latter is associated with the solution of oxygen in the metal. The effects of the mechanism of oxygen diffusion, of pretreatment and microstructure of alloys, and of alloy composition are discussed. Some aspects of reactions involving sulphur are also reviewed. Author

**N73-23605** Cranfield Inst of Technology (England)  
**WHAT IS THE ROLE OF STRESS IN OXIDATION, INCLUDING BOTH EXTERNALLY APPLIED AND GROWTH STRESSES? WHAT ARE THE MODES OF STRESS-RELAXATION? HOW DOES THERMAL CYCLING AFFECT THE STRESSES AND STRESS RELAXATION?**

P. Hancock. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 117-128. refs (For availability see N73-23597 14-17)

The isothermal stresses generated during oxidation can be attributed to four main causes: (1) the volume ratio between the metal and the oxide formed; (2) the epitaxial relationship between the oxide and the metal; (3) composition changes in either the metal or the oxide; and (4) the influence of vacancies generated during oxidation. In any single oxidation process all of these factors may contribute, but the influence of component geometry on these processes is often critical and invariably neglected. Mechanisms of stress relief include: cracking of the oxide film; plastic deformation of the scale; and in some circumstances deformation of the underlying metal. The mechanisms of plastic deformation of the scales are reviewed and the effects of thermal stresses considered. Author

**N73-23606** Yale Univ., New Haven, Conn. Dept of Engineering and Applied Science  
**ENVIRONMENTAL EFFECTS ON GAS-METAL REACTIONS AT ELEVATED TEMPERATURES**

D. E. Rosner. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 129-144. refs (For availability see N73-23597 14-17)

To anticipate the effects of unusually severe operating conditions, or to design readily interpretable oxidation kinetic experiments, consideration is given to the conditions of convection, diffusion, and chemical change in the immediate vicinity of the gas/solid interface. Recently exploited methods are outlined for accomplishing this by combining simple conservation principles with computational techniques and experimental data developed by chemical, mechanical, and aeronautical engineers for dealing with similar physical situations. Important effects on gas/solid oxidation rates associated with gas flow rate, enthalpy, pressure level, and/or chemical composition (especially dissociation) are discussed, both from the points of view of making reliable rate predictions based on available chemical and physical data, and designing kinetic experiments from which fundamental information can be extracted. Author

**N73-23607** Ohio State Univ., Columbus

**VAPORIZATION LOSSES FROM Cr<sub>2</sub>O<sub>3</sub> PROTECTIVE SCALES**

R. A. Rapp. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 147-154. refs (For availability see N73-23597 14-17)

Vaporization thermodynamics and kinetics are reviewed. The vaporization of Cr<sub>2</sub>O<sub>3</sub> scales occurs with the formation of CrO<sub>3</sub> and Cr(OH)<sub>3</sub> vapor species. The maximum possible rate of vaporization is given by the Hertz-Langmuir equation, but in the practical case the rate is limited by mass transport through a stagnant boundary layer, the thickness of which depends on the local gas velocity. In turbulent near-sonic flow the vaporization rate may therefore approach the theoretical maximum. It is suggested that the only possibility for the use of protective Cr<sub>2</sub>O<sub>3</sub> scales in reactive high-velocity atmospheres is to separate the Cr<sub>2</sub>O<sub>3</sub> scale from the environment by a compact and stable surface oxide which is low in the activity of Cr<sub>2</sub>O<sub>3</sub>. However, external spinel scales are generally spalled through thermal shock. There is considerable evidence to suggest that the formation of a protective alpha-Al<sub>2</sub>O<sub>3</sub> scale effectively inhibits the evaporative loss of chromium from an alloy. Author

**N73-23608** Pratt and Whitney Aircraft, East Hartford, Conn.  
**ON THE EFFECTS OF OXIDE DISPERSIONS AND RARE-EARTH TYPE ELEMENTS ON THE OXIDATION OF Cr AND Al-CONTAINING ALLOYS**

F. S. Pettit. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 155-172. refs (For availability see N73-23597 14-17)

The effects of oxide dispersions and rare-earth type elements on the oxidation of alloys upon which Cr<sub>2</sub>O<sub>3</sub> or Al<sub>2</sub>O<sub>3</sub> scales are formed is discussed. It is shown that oxide dispersions and rare-earth type elements can both apparently affect the adherence, growth rate, and growth mechanism of Cr<sub>2</sub>O<sub>3</sub> as well as the selective oxidation of chromium in alloys. In the case of alloys upon which Al<sub>2</sub>O<sub>3</sub> scales are formed, however, oxide dispersions and rare-earth elements appear to affect only the adherence of the scale. The differences between effects produced by oxide dispersions and rare-earth type elements is examined. Author

**N73-23609** Liverpool Univ. (England)

**THE APPLICATION OF MULTICOMPONENT DIFFUSION THEORY TO THE OXIDATION AND CORROSION OF COMPLEX SUPERALLOYS**

D. P. Whittle. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 173-200. refs (For availability see N73-23597 14-17)

The relevant phenomenological equations for multicomponent diffusion and methods of obtaining their solution are briefly presented. Possible forms which the calculated diffusion paths may adopt are indicated and the relevance of these to the oxidation and sulfation of alloys is discussed. The multicomponent diffusion equation was solved for transport in the alloy when one of the alloy components was being selectively removed by oxidation or sulfation. Two cases are considered: where the oxidant is insoluble in the alloy when the composition of the alloy/scale interface is important in determining which phase is stable in the scale; and when the oxidant is soluble and can diffuse into the alloy, possibly producing internal precipitation of sulphide or oxide. The relevant conditions for internal precipitation are also presented. In both cases, the importance of diffusional interaction is stressed. Author

**N73-23610** Admiralty Materials Lab., Poole (England)

**WHAT ARE THE SEPARATE AND INTERACTING ROLES OF SULPHUR, SODIUM AND CHLORIDE IN HOT CORROSION?**

J. F. G. Conde. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 203-220. refs (For availability see N73-23597 14-17)

The origins of the sulfur, sodium, and chloride contaminants are discussed and the conditions existing in the gas turbine are examined. The chemistry of contaminants in the combustion environment is introduced and evidence is cited to show that in the short residence times available, gas phase sulfation of chloride

is not significant. The mechanism of salt deposition in the gas turbine on nozzles and blades is considered briefly and the role of the obvious contaminants, sulfur, sodium, and chloride is examined in relation to sulfidation and accelerated oxidation. A model is suggested in which periodically extremely local non-equilibrium conditions arise on the surface of nozzles and turbine blades due to impaction of sea-salt particles. It is suggested that such conditions may permit chloride to destroy the integrity of protective scale layers under low oxygen pressure conditions existing beneath liquid sulfate deposits. Author

**N73-23611** Centre National de Recherches Metallurgiques, Liege (Belgium)

**WHAT ARE THE EFFECTS OF ALLOYING ELEMENTS SINGLY OR IN COMBINATION ON HOT CORROSION?**

A. Davin and D. Coutouradis. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 221-233. refs (For availability see N73-23597 14-17)

As single additions only chromium or aluminium are reported to improve the oxidation resistance of nickel and cobalt appreciably, due to their forming protective scales of Cr<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub> respectively at sufficiently high concentrations. When the two elements are added together, the presence of the chromium causes a stable layer of Al<sub>2</sub>O<sub>3</sub> to develop at lower aluminium concentrations than in the binary systems, due to the gettering effect of the chromium in the metal which impedes the inward diffusion of oxygen and prevents internal oxidation of the aluminium. Author

**N73-23612** Naval Ship Research and Development Center, Annapolis, Md

**ARE COBALT-BASE ALLOYS INTRINSICALLY MORE RESISTANT TO HOT CORROSION THAN ALLOYS BASED ON NICKEL?**

W. L. Wheatfall. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 235-254. refs (For availability see N73-23597 14-17)

A literature search was made in an effort to determine if cobalt-base alloys are intrinsically better than alloys based on nickel relative to hot-corrosion resistance. Results of the search did not confirm whether cobalt alloys were inherently more resistant than nickel alloys. Failure to resolve this controversy was due mainly to two factors: (1) insufficient hot-corrosion data comparing pure nickel and cobalt, and (2) contradictions with regard to the roles of sulfur and the liquid sulfide phase in the hot corrosion process. A discussion and comparison of results of a number of investigations are provided along with the listing of several questions which may serve as the basis for future research efforts to finally resolve whether or not cobalt-base alloys are intrinsically more hot-corrosion resistant than alloys based on nickel. Author

**N73-23613** International Nickel Co., Ltd., Birmingham (England)

**CAN FUEL ASH CORROSION BY VANADIUM BE COMBATED BY ALLOYING OR COATING WITHOUT THE USE OF FUEL ADDITIVES?**

K. J. Williams and P. J. Perry. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 255-266. refs (For availability see N73-23597 14-17)

Materials for nozzle guide vanes and turbine blades subject to attack by the products of combustion of vanadium-containing fuels are investigated. Previous operating experience of industrial gas turbines burning residual fuel is referred to, and current ASTM fuel specifications are considered. Relevant developments with alloys and coatings are reviewed. Recently announced alloys containing 35% - 50% chromium offer promising corrosion resistance, and an indication of the strength attainable in the 50% Cr base is given. High chromium coatings applied by pack chromising have performed well in recent burner rig tests. There is a need for more comprehensive testing of these new materials under realistic conditions, and over a range of vanadium contents. Author

**N73-23614** Nancy Univ (France)

**WHAT ARE THE PROSPECTS FOR THE SUCCESSFUL APPLICATION OF COATED REFRACTORY METALS IN UNCOOLED TURBINES? [QUEL EST L'AVENIR DES ALLIAGES REFRACTAIRES PROTEGES DANS LA CONSTRUCTION DES TURBOMACHINES?]**

B. Roques. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 269-282. refs. In FRENCH, ENGLISH summary (For availability see N73-23597 14-17)

Various protective coatings are investigated to determine the most effective application for refractory metal alloys used in the structural makeup of turbine engines. The results indicated that coatings based on SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> constitute foundations from which improved protective oxides may be developed. J. M. M.

**N73-23615** Liverpool Univ (England)

**ARE THERE NEW APPROACHES TO ALLOYING WHICH MAY PRODUCE OXIDATION-RESISTANT REFRACTORY METAL ALLOYS?**

J. Stringer. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 283-294. refs (For availability see N73-23597 14-17)

The oxidation mechanisms of Nb, Ta, Mo and W are briefly reviewed. Nb and Ta form non-protective porous scales of the pentoxides, and at the same time oxygen dissolves in the metal producing severe embrittlement. It was found that at elevated temperatures, both Mo and W form volatile oxides, and reduction in the oxidation rate requires the stabilization of a foreign oxide or the development of a protective noble metal-rich layer at the surface. Some molybdates and tungstates appear to have promising properties, and chromium-rich alloys forming Cr<sub>2</sub>O<sub>3</sub> layers also represent significant improvements. Unfortunately, all alloys so far developed which have significantly improved oxidation resistance are also very brittle. Author

**N73-23616** Aerospace Research Labs., Wright-Patterson AFB, Ohio

**PROSPECTS FOR OXIDATION RESISTANT REFRACTORY COMPOUNDS**

Norman M. Tallan. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 295-309. refs (For availability see N73-23597 14-17)

Recent results of static and dynamic oxidation studies of materials which combine optimum resistance to corrosion, thermal shock, fracture, fatigue, etc. are presented. Particular attention is directed to the potential of such materials as Zr<sub>5</sub>C<sub>3</sub>, HfB<sub>2</sub>, SiC, Si<sub>3</sub>N<sub>4</sub> and their combinations in a range of technologically important applications, including gas turbines, hypersonic and re-entry vehicles. Relation of the details of the oxidation processes, their dependence on fabrication variables, and their effect on material performance are emphasized. The possible use of these and related high temperature materials as coatings for refractory metals and alloys is discussed. Author

**N73-23617** Battelle Columbus Labs., Ohio

**CONCLUDING DISCUSSION**

R. I. Jaffee and T. F. Kearns (Naval Air Systems Command). In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 313-314. (For availability see N73-23597 14-17)

Reaction kinetics relative to corrosion and oxidation resistance in refractory metal alloys are discussed. Emphasis is placed on the application of these alloys in the elevated temperature environments of gas turbine engines. The areas dealt with include: scale lattice defects, evaporation, diffusion, hot corrosion reaction, protective coatings, scale behavior in thermal shock, applied stresses in oxidation, effects of composition variables on scale plasticity, and testing procedures. J. M. M.

**N73-23618** Battelle Columbus Labs., Ohio

**ANNEX B. NATO NATIONAL REPORTS ON HIGH TEMPERATURE CORROSION OF AEROSPACE ALLOYS. A TOPICAL LISTING OF THE RESEARCH PROGRAMS**

Ian G. Wright. In AGARD High Temp Corrosion of Aerospace Alloys. Mar 1973. p 321-350. (For availability see N73-23597 14-17)

The data presented in this compilation represent much of the current research and development work in NATO countries on high temperature corrosion of aerospace alloys. Author

**N74-23108#** Advisory Group for Aerospace Research and Development, Paris (France)

**METALLURGICAL ASPECTS OF FATIGUE AND FRACTURE** AGARD R 610# Avail NTIS HC \$7.75

The proceedings of a conference to investigate the fatigue and fracture behavior of aerospace structural alloys are presented. The effect of heat treatment to prevent stress corrosion was analyzed to determine possible changes in the mechanical properties of the materials. The subjects discussed include the following: (1) metallurgical aspects of fatigue and fracture toughness; (2) developments in fatigue and fracture; (3) thermomechanical procedures to improve the properties of high strength aluminum-magnesium-zinc-copper alloys; and (4) the influence of microstructure on the growth of fatigue cracks. For individual titles see N74-23109 through N74-23112.

**N74-23109** Royal Aircraft Establishment, Farnborough (England) Materials Dept.

**THE METALLURGICAL ASPECTS OF FATIGUE AND FRACTURE TOUGHNESS**

P. J. E. Forsyth. In AGARD Met Aspects of Fatigue and Fracture Toughness, Dec. 1973, p. 1-22, refs. (For availability see N74-23108 14-17).

An analysis of the cause of fatigue cracks in materials after a period of repeated stressing is presented. The effects of crystal structure and slip plane cracks are discussed. The application of thermomechanical treatment for improved mechanical properties is described. The effects of anisotropy of micro and macro structure are reported with respect to total fatigue life and crack propagation rates. The fracture toughness of materials is analyzed to show the effects of crystal structure and metal working. Mathematical models are developed to express fracture toughness and plastic deformation. Author

**N74-23110** Connecticut Univ., Storrs

**SOME RECENT DEVELOPMENTS IN FATIGUE AND FRACTURE**

A. R. Rosenfeld and A. J. McEvily (Battelle Columbus Labs). In AGARD Met Aspects of Fatigue and Fracture Toughness, Dec. 1973, p. 23-54, refs. (For availability see N74-23108 14-17).

The microstructural origins of the fracture resistance of high strength steels are analyzed. Curves are presented to show schematic crack growth versus stress intensity. The mechanisms considered are fatigue cracking and stress corrosion cracking. Both phenomena exhibit three stages of crack growth as follows: (1) a threshold below which crack growth is not detected; (2) a steady state region, constant velocity for environmental attack and power law behavior for fatigue; and (3) an instability characterized by the fracture toughness for plane strain thick section behavior. Author

**N74-23111** Istituto Sperimentale dei Metalli Leggeri, Novara (Italy)

**IMPROVEMENT OF THE PROPERTIES OF HIGH STRENGTH Al-Zn-Mg-Cu ALLOYS BY THERMOMECHANICAL PROCEDURES**

E. DiRusso and S. Signoretti (Aeron. Militare Italiana). In AGARD Met Aspects of Fatigue and Fracture Toughness, Dec. 1973, p. 55-76, refs. (For availability see N74-23108 14-17).

A thermomechanical processing technique for producing plates and forgings of 7000 series alloys (7075, 7049, 7475, 7050, etc.) showing a less transverse effect than similar conventionally processed materials was developed. This procedure, called Intermediate Thermomechanical Treatments (ITMT), is based on a combination of warm deformations and heat treatments which involve the recrystallization of the ingot in small equiaxed grains in an intermediate (or final) stage of the working. As a result of the processing, the alloys exhibit better ductility, toughness and stress corrosion properties for a given strength than conventionally processed materials, mainly in the short transverse direction. Moreover, it has been found that the contemporary application

of ITMT and final (FTMT) thermomechanical treatments of TAAH type, which, as is known, cause a super-hardening effect with an acceptable loss in ductility, may lead to decidedly new products with properties that are much superior to those of commercial traditional products. Author

**N74-23112** PSI-Trans Corp., El Segundo, Calif.

**INFLUENCE OF MICROSTRUCTURE ON THE GROWTH OF FATIGUE CRACKS**

G. Sertour and C. Bathias. In AGARD Met Aspects of Fatigue and Fracture Toughness, Dec. 1973, p. 77-90, refs. (For availability see N74-23108 14-17).

The application of the failure mechanism concepts to the development of fatigue induced cracks is discussed. The influence of microstructure on the propagation of fatigue induced cracks is analyzed. The metallurgical parameters which play a part at the very level of crack propagation mechanisms are examined. It is stated that the most important parameter which governs the development of fatigue induced cracks is the nature of the plastic deformations which occur at the crack tip. Such deformations are essentially related to the slip character and to the stacking fault energy. The influence of structure on fatigue induced crack development is reviewed with emphasis on the formation of striations and on the environment-structure interaction on crack growth. Author



## 18 MATERIALS, NONMETALLIC

Includes corrosion, physical and mechanical properties of materials (e.g., plastics), and elastomers, hydraulic fluids, etc. For basic research see 06 Chemistry. For related information see also 17 Materials, Metallic, 27 Propellants, and 32 Structural Mechanics.

**N71-25027\*** Advisory Group for Aerospace Research and Development, Paris (France).

### HANDBOOK OF BRITTLE MATERIAL DESIGN TECHNOLOGY

W. H. Dukes, Feb. 1971, 161 p., illus.

(AGARD AG-152-71, AGARDOGRAPH-152) Avail. NTIS

Structural data on brittle nonmetallic refractory materials such as oxides, carbides, nitrides, and graphite are provided for use in designing reentry vehicles and propulsion systems. The term brittle materials is used to describe materials which show no plastic deformation under stress, but deform elastically until failure. The principles and practices for achieving reliability with structures constructed with brittle materials are described in detail. Design stresses, stress analysis, mechanical properties, and design criteria are discussed. F.O.S.

**N71-27038\*** Advisory Group for Aerospace Research and Development, Paris (France).

### THE CHARACTERIZATION AND APPLICATION OF MATERIALS

May 1971, 151 p., refs.

(AGARD-LS-51-71) Avail. NTIS

#### CONTENTS

1. A SYSTEMS APPROACH TO THE SELECTION AND APPLICATION OF MATERIALS. R. Maddin (Pa. Univ., Philadelphia), 20 p., refs. (See N71-27039 15-18).

2. CHARACTERIZATION, SELECTION, AND USE OF HIGH STRENGTH STEELS. W. S. Owen (Northwestern Univ.), 19 p., refs. (See N71-27040 15-17).

3. NATURE, STATUS, AND SELECTION OF CERAMIC MATERIALS. J. A. Pask (Calif. Univ., Berkeley, Lawrence Radiation Lab.), 66 p. (See N71-27041 15-18).

4. CHARACTERIZATION, SELECTION, AND USE OF POLYMERIC MATERIALS. C. Wippler (Ecole d'Application des Hauts Polymères, Strasbourg, France), 14 p. (See N71-27042 15-18).

5. FIBRE REINFORCED MATERIALS. A. Kelly (Nat. Physical Lab., Teddington, England), 12 p. (See N71-27043 15-18).

6. NEW BASIS OF CLASSIFICATION AND SELECTION OF ALUMINUM ALLOYS. J. Tigeot (Foréal, Issore, France), 28 p., refs. (See N71-27044 15-15).

7. CHARACTERIZATION, SELECTION, AND USE OF TITANIUM BASE ALLOYS. R. Syre (SOCIÉTÉ TREFIMET-AUX ARGENTEUIL, FRANCE), 46 p., refs. (See N71-27045 15-17).

**N71-27039\*** Pennsylvania Univ., Philadelphia, School of Metallurgy and Materials Science.

### A SYSTEMS APPROACH TO THE SELECTION AND APPLICATION OF MATERIALS

Robert Maddin. In: AGARD, The Characterization and Appl. of Mater., May 1971, 20 p., refs. (See N71-27038 15-18).

Avail. NTIS

Analyses undertaken by a materials engineer in a materials system concept consist of: market applications; range of required

parts; environmental effects on exposed part; material properties in relation to environment; and selection of materials and feasible manufacturing processes. Characterization of a material includes precise descriptions of its chemical composition, impurities, and factors associated with grain and substructures. G.G.

**N71-27040\*** Northwestern Univ., Evanston, Ill., Technological Inst.

### CHARACTERIZATION, SELECTION, AND USE OF HIGH STRENGTH STEELS

W. S. Owen. In: AGARD, The Characterization and Appl. of Mater., May 1971, 19 p., refs. (See N71-27038 15-18).

Avail. NTIS

The principles and ideas on which modern ultra-high strength steels have been developed are outlined and a few concepts of basic importance are illustrated by a description of specific alloys and thermal and mechanical treatments which are applied to them. Considered exclusively are those alloys intended to possess a very high strength, as defined by the yield stress or the flow stress, at a small offset (less than 0.2% strain) combined with acceptable ductility. It is assumed that components made from these steels are subjected to static loading, a slow applied strain rate or very low frequency cyclic loading at temperatures within 100 degrees of room temperature. Of primary importance is the resistance of these alloys to stress corrosion and related effects. Most of the features of the structure of importance in this context are those which can be studied by optical microscopy. Author

**N71-27041\*** California Univ., Berkeley, Lawrence Radiation Lab., Inorganic Materials Research Div.

### NATURE, STATUS, AND SELECTION OF CERAMIC MATERIALS

Joseph A. Pask. In: AGARD, The Characterization and Appl. of Mater., May 1971, 66 p. Sponsored by AEC. (See N71-27038 15-18).

Avail. NTIS

Ceramic materials are identified as having ionic covalent bonding being composed of compounds, and being either crystalline or glassy. The oxides are of particular interest because of their chemical stability up to high temperatures. Brittle behavior makes them sensitive to flaws, either intrinsic or extrinsic, thus requiring a uniform distribution of uniform flaws to achieve reliability. Intrinsic flaws can be correlated with character features. Extrinsic flaws in themselves are character features. Both of these features can be correlated with mechanical properties and behavior. A number of applications of ceramic materials based on their unique properties of chemical resistance, high strength, density ratios, high modulus of elasticity, density ratios, hardness, optical transparency, and electrical resistance are revised. Author

**N71-27042\*** Ecole d'Application des Hauts Polymères, Strasbourg (France).

### CHARACTERIZATION, SELECTION, AND USE OF POLYMERIC MATERIALS (PROPRIÉTÉS, SELECTION ET APPLICATIONS DES POLYMERES)

C. Wippler. In: AGARD, The Characterization and Appl. of Mater., May 1971, 14 p. In FRENCH, ENGLISH summary. (See N71-27038 15-18).

Avail. NTIS

Polymeric substances are classified as either thermosetting or thermoplastic resins. The first category includes phenolic resins, urea, and melamin formaldehyde resins, epoxy resins, unsaturated polyesters, and elastomers. These are polymeric substances, the synthesis of which is achieved during the processing by the curing phase. The second category includes polyvinyl resins, polyethylene, polyvinyl chloride, polystyrene. Their state essentially depends on temperature and time scale. Their properties are influenced not only by their chemical nature, but also by their molecular weight and molecular structure. The selection of a polymeric substance for a

given application depends on a number of physico-chemical characteristics: thermal characteristics, mechanical characteristics, electric or optical characteristics, and on its cost. Author

**N71-27043#** National Physical Lab. Teddington (England)  
**FIBRE REINFORCED MATERIALS**

A. Kelley. In AGARD: The Characterization and Appl. of Mater. May 1971. 12 p. (See N71-27038 15-18)

Avail. NTIS

A new range of materials which are made of strong, stiff fibers, embedded in a matrix which may be resin, metal, or even glass is considered. Some of the properties of the new strong fibers are listed, their arrangements in a fiber-reinforced body are strikingly similar to that found in natural materials. The present state of knowledge about the principles of fiber reinforcement is reported. A clear distinction is made between a brittle solid which breaks sharply with little and no flow, and a fragile solid which breaks easily. Cracks which usually lead to breaking behave differently in a fragile solid and in a fibrous aggregate, though both are brittle.

Author

**N71-27044#** Forgeal, Issoire (France)

**NEW BASIS OF CLASSIFICATION AND SELECTION OF ALUMINUM ALLOYS [NOUVEAUX CRITERES DE CARACTERISATION ET DE SELECTION DES ALLIAGES D'ALUMINUM]**

J. Tigout. In AGARD: The Characterization and Appl. of Mater. May 1971. 28 p. refs. In FRENCH and ENGLISH. (See N71-27038 15-18)

Avail. NTIS

Aluminum alloys are the material most widely used in modern airframe construction since, even where they are designed to fly at around Mach 2.5, military aircraft do not hold these speeds long enough for the temperature increase due to airflow to affect the performance of the light alloys involved. The aluminum alloys most frequently used are aluminum-copper-magnesium alloys, or aluminum-zinc-magnesium-copper alloys. Reviewed are attempts to improve the normal mechanical properties of alloys, refine assessment of the susceptibility of an alloy to brittle fracture, obtain greater understanding of corrosion performance, and determine fatigue performance.

Author

**N71-27045#** Societe Trefimetaux, Argenteuil (France)  
**CHARACTERIZATION, SELECTION AND USE OF TITANIUM BASE ALLOYS [CARACTERISATION, SELECTION ET UTILISATION DES ALLIAGES DE TITANE]**

R. Syre. In AGARD: The Characterization and Appl. of Mater. May 1971. 46 p. refs. In FRENCH and ENGLISH. (See N71-27038 15-18)

Avail. NTIS

The advantages of titanium alloys are based primarily on their mechanical property density ratio developed by addition of alloying elements and heat treatments. Alloy selection for the two major applications (airframes and jet engines) is based on stringent characterization criteria, such as fracture toughness, stress corrosion resistance, and fatigue strength, in addition to creep resistance, low cycle fatigue strength, and thermal stability for jet engine design. Fasteners, hydraulic tubings and castings provide new areas of application for titanium. Engineering properties vary strongly with the alloy microstructure.

Author

**N72 12492#** Advisory Group for Aerospace Research and Development, Paris (France)  
**COMPOSITE MATERIALS**

Sep. 1971. 225 p. refs. Partly in ENGLISH, partly in FRENCH. Conf. held at Paris, 2-3 Apr. 1970.

(AGARD CP 63 71, AGARD CONF Proc 63). Avail. NTIS

**CONTENTS**

1. PANEL MEMBERS AND MEMBERS OF THE WORKING GROUP ON COMPOSITE MATERIALS. p. iii

2. FOREWORD. p. iv

3. SHORT SURVEY OF THE SYMPOSIUM. G. C. Leomand. p. v

4. FABRICATION D'EPROUVETTES STRATIFIEES UNIDIRECTIONNELLES. C. Genin. 8 p.

5. DETERMINATION OF ELASTIC CONSTANTS OF A UNIDIRECTIONALLY REINFORCED PLASTIC. G. J. Spies and Th. de Jong. 15 p.

6. MECHANICAL PROPERTIES OF EPOXY SILICA COMPOSITE MATERIALS. P. DeMeester, P. Dambre, and A. Deruyttere (Louvain Univ., Belgium). 11 p. refs. (See N72 12493 03-18)

7. THE NPL ULTRASONIC TANK: ITS USES IN POLYMER AND FIBRE COMPOSITE TESTING. M. F. Markham (Nat'l Physical Lab., Teddington, England). 8 p. refs. (See N72-12494 03-11)

8. MODULUS OF ELASTICITY MEASUREMENTS ON RESIN FIBER COMPOSITES. H. Guyot and M. Bedard (Office Nat'l D'Etudes et de Rech. Aeronautiques). 13 p. refs. (See N72-12495 03-18)

9. LINEAR AND NONLINEAR CHARACTERISTICS OF A UNIDIRECTIONAL EPOXY SILICON REINFORCED COMPOSITE. J. Pabiot (Centre D'Etude des Matieres Plastiques, Paris, France). 15 p. refs. (See N72-12496 03-18)

10. ELASTIC CONSTANTS EVALUATION OF A REINFORCED PLASTIC MATERIAL. A. Bracco, G. Mannone, and M. Sattin (Fiat S.P.A., Turin, Italy). 24 p. refs. (See N72-12497 03-18)

11. ELASTIC CHARACTERIZATION OF FIBER REINFORCED COMPOSITES. J. M. Slepetz (Army Mater. and Mechanics Res. Center, Watertown, Mass.). 10 p. refs. (See N72-12498 03-18)

12. MECHANICAL BEHAVIOR OF SiO<sub>2</sub> EPOXY COMPOSITE. F. Darwish and A. S. Tetelman (Calif. Univ., Los Angeles). 7 p. refs. (See N72-12499 03-18)

13. DETERMINATION OF MATRIX AND FILAMENT STRESS-STRAIN PROPERTIES FROM TESTS MADE ON COMPOSITES. R. Papirno and J. Slepetz (Army Mater. and Mechanics Res. Center, Watertown, Mass.). 4 p. refs. (See N72-12500 03-18)

14. DISCUSSION OF STEEL-WIRE-REINFORCED ALUMINUM ALLOYS INVESTIGATED AT BATTELLE-INSTITUT e.V., FRANKFURT AM MAIN. U. Seidelmann (Batelle Inst., Frankfurt AM Main, West Ger.). 4 p. refs. (See N72 12501 03-17)

15. STRENGTHENING OF ALUMINUM BY EXPLOSIVE INCORPORATION OF BERYLLIUM WIRES. C. V. Jarvis and P. M. B. Slate (Atomic Weapons Res. Estab., Foulness, England). 19 p. refs. (See N72-12502 03-17)

16. PRODUCTION OF ALUMINUM-BERYLLIUM COMPOSITES BY HOT PRESSING. R. Cousserans (Groupe Pechiney Voreppe (France)). 6 p. (See N72-12503 03-17)

17. MECHANISMS OF FATIGUE IN FILAMENT REINFORCED METALS. J. R. Hancock (Midwest Res. Inst., Kansas City, Mo.). 21 p. refs. (See N72-12504 03-17)

18. A NEW TEST FOR THE GLASS-TO-RESIN BOND LIFE IN GHP: COMPARISON OF TYPICAL SYSTEMS EXPOSED TO WATER. M. H. Stone (Rubber and Plastics Res. Assoc. of Great Britain). 12 p. refs. (See N72 12505 03-18)

19. WETTING AND TREATMENT OF REINFORCING FIBER FILAMENTS FOR ORGANIC MATERIALS. G. Mavel (Inst. de Rech. de Chimie Avancee, Paris, France). 9 p. refs. (See N72-12506 03-18)

20. STUDY OF INTERACTION BETWEEN A BERYLLIUM FIBER AND AN ALUMINUM MATRIX. J. P. Trotter and R. Graf (Office Nat'l D'Etudes et de Rech. Aeronautiques, Paris, France). 9 p. refs. (See N72 12507 03-17)

21. CALCULATING AND PREDICTING VISCOELASTIC CONSTANTS OF COMPOSITE MATERIALS. N. P. Vinh Young (Inst. Supérieur des Matériaux et de la Cons.). 28 p. refs. (See N72 12508 03-18)

22. REMARQUES AU SYMPOSIUM SUR LES MATERIAUX COMPOSITES. J. Lemaitre. 2 p.

23. REMARQUES AU SYMPOSIUM SUR LES MATERIAUX COMPOSITE DE L'AGARD. J. Pabiot. 2 p.

24. DEVELOPPEMENT EVENTUEL DU PROGRAMME. G. Dixmier. 2 p.

25. APPENDIX: DISCUSSIONS ON PRESENTED PAPERS. 8 p.

**N72-12493#** Louvain Univ. (Belgium). Inst. voor Metaalkunde  
**MECHANICAL PROPERTIES OF EPOXY-SILICA COMPOSITE MATERIALS**

P. deMeester, P. Dambre, and A. Deruytère. In AGARD Composite Mater. Sep 1971. 11 p. refs. (See N72-12492 03-18)

Avail. NTIS

Composite materials consisting of an epoxy matrix longitudinally reinforced by oriented silica fibres have been tested for their mechanical properties. Primarily the elastic coefficients have been measured. For this purpose static and dynamic measurements have been performed. Specimen forms and test results are discussed. Other mechanical properties (UTS) are also presented and discussed in view of the application of such fibre reinforced materials as structural elements. Author

**N72-12494#** National Physical Lab., Teddington (England). Div. of Molecular Science

**THE NPL ULTRASONIC TANK. ITS USES IN POLYMER AND FIBRE COMPOSITE TESTING**

M. F. Markham. In AGARD Composite Mater. Sep 1971. 8 p. refs. (See N72-12492 03-18)

Avail. NTIS

Measurement of ultrasonic attenuation on composites has been shown to be a valuable qualitative method of testing these materials for voids or similar defects. Existence of these does seriously reduce the strength and indeed the elastic constants. It is therefore highly desirable that all samples are tested in this manner before further tests are carried out. The method has been applied to two composites: silica epoxy and silica phenolic sheets. Values of their elastic constants are given in the appendix. Author

**N72-12495#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**MODULUS OF ELASTICITY MEASUREMENTS ON RESIN FIBER COMPOSITES [MESURES DE MODULES ELASTIQUES SUR COMPOSITE FILS-RESINE]**

H. Guyot and M. Hédard. In AGARD Composite Mater. Sep 1971. 13 p. refs. In FRENCH, ENGLISH summary. (See N72-12492 03-18)

Avail. NTIS

Test specimen have a rectangular section of 4 x 10 mm. Elastic deformations are measured under a rather low stress. Three extensometers are mounted together to measure the variations of total width, of total thickness, and the deformation stress and test specimen lengths. Within one percent measurements are reproducible when made on the same test specimen of furnished materials. But there is a rather great dispersion between different specimens. Moreover test specimen stressed perpendicularly to silica yarns show a rather consequential delayed elasticity. Author

**N72-12496#** Centre d'Etude des Matières Plastiques, Paris (France)

**LINEAR AND NONLINEAR CHARACTERISTICS OF A UNIDIRECTIONAL EPOXY-SILICON REINFORCED COMPOSITE**

J. Pabiot. In AGARD Composite Mater. Sep 1971. 15 p. refs. In FRENCH, ENGLISH summary. (See N72-12492 03-18)

Avail. NTIS

A method for determining independent mechanical characteristics of an epoxy-silica composite material in which the reinforcement is unidirectional is presented. The material takes the form of small dimension sheets. Its characteristics must allow the quantitative response prediction to all states of stress. In the linear domain the compliance tensor, and in the non-linear domain a criterion of breaking strength is defined theoretically. The validity of the hypotheses and results have been confirmed by submitting the characteristics as a function of the angular position of the axes. The discussion of the results concerns chiefly the percentage of fiber, its distribution and the physical appearance of the material resulting from certain stress conditions. Author

**N72-12497#** Fiat SpA, Turin (Italy). Lab. Ricerche e Controlli Auto-Avto

**ELASTIC CONSTANTS EVALUATION OF A REINFORCED PLASTIC MATERIAL**

A. Bracco, G. Mannone, and M. Sattin. In AGARD Composite Mater. Sep 1971. 24 p. refs. (See N72-12492 03-18)

Avail. NTIS

A theoretical and experimental analysis has been performed to evaluate the elastic constants of a silica-epoxy composite material. From a theoretical standpoint the material under test has been considered as an homogeneous body and assumed to be isotropic in the plane orthogonal to the fibers direction. Under these assumptions one can show that five independent elastic constants are sufficient to describe the elastic properties of the composite material. The values of these constants have then been plotted versus specific weight and strain rate of the samples by the use of ad hoc suitable equipments. Author

**N72-12498#** Army Materials and Mechanics Research Center, Watertown, Mass. Theoretical and Applied Mechanics Research Lab

**ELASTIC CHARACTERIZATION OF FIBER REINFORCED COMPOSITES**

J. M. Slepetz. In AGARD Composite Mater. Sep 1971. 10 p. refs. (See N72-12492 03-18)

Avail. NTIS

The large scatter in test data observed is consistent with previous experience in fiber reinforced materials. Such variance is usually due in part to fabrication variables, variation in constituent properties, and deficiencies in test methods. It also has been suggested that local stress concentrations, particularly in transverse normal and shear tests, affect behavior. In the gross scale and account for part of the data spread. The specimens were prepared with most of the fabrication variables eliminated, yet the scatter in test results was still excessive. This suggests that conventional test methods are at fault or that wide variations in composite properties are intrinsic to this class of materials. In any case the designer's problem of predicting structural behavior or of specifying required properties of composites is considerably magnified by such uncertainties concerning material properties. Author

**N72-12499#** California Univ., Los Angeles

**MECHANICAL BEHAVIOR OF SiO<sub>2</sub>-EPOXY COMPOSITE**

F. Darwish and A. S. Tetelman. In AGARD Composite Mater. Sep 1971. 7 p. refs. (See N72-12492 03-18)

Avail. NTIS

The effects of temperature and fiber orientation on the load carrying capacity, strength and fracture mode of SiO<sub>2</sub> epoxy resin composites have been investigated by means of slow bend and impact tests. Although tough and strong when loaded parallel to its fibers the composite is shown to be weak and brittle when loaded transversely. The composite exhibited little or no notch sensitivity for notches machined along planes normal to the fibers, whereas for the case of notches machined parallel to the fibers the composite showed considerable notch sensitivity that depended on the test temperature. Increase in test temperature had the effect of reducing the load carrying capacity of both the notched and unnotched samples in both the slow bend and impact loading. Impact energy values measured for the specimens loaded parallel to their fibers showed a slight decrease with the rise in test temperature. Author

**N72-12500#** Army Materials and Mechanics Research Center, Watertown, Mass. Theoretical and Applied Mechanics Research Lab

**DETERMINATION OF MATRIX AND FILAMENT STRESS-STRAIN PROPERTIES FROM TESTS MADE ON COMPOSITES**

Ralph Papirer and John M. Slepetz. In AGARD Composite Mater. Sep 1971. 4 p. refs. (See N72-12492 03-18)

Avail. NTIS

A simple method has been developed for the determination of the effective in situ linear and nonlinear stress-strain response of the matrix and reinforcement from load-strain measurements made on composites. Two specimens with slightly different but predetermined value volume fractions of reinforcement are tested. An analysis of the load-strain data from the two specimens yields the average for the two specimens of stress-strain data for the reinforcement and for the matrix. It is shown that the method is independent of the shape of the component stress-strain curves and may be applied in the linear and nonlinear regions. General principles of specimen pair design are derived based upon a sensitivity analysis of the method which takes into account the precision of the measuring apparatus and the relative stiffnesses of the components of the composites.

Author

**N72-12501#** Battelle Inst., Frankfurt am Main (West Germany). **DISCUSSION OF STEEL-WIRE-REINFORCED ALUMINUM ALLOYS INVESTIGATED AT BATTELLE INSTITUT e.V., FRANKFURT AM MAIN**

U. Seidelmann. In AGARD Composite Mater. Sep 1971. 4 p. refs. (See N72-12492 03 18)

Avail. NTIS

Results obtained in tensile strength measurements made on steel wire reinforced aluminum alloys are presented. Carbon steel wire whose final strength after incorporation in the composite was about 140 plus or minus 10 kg sq mm, was coated with aluminum alloys and after hot pressing first subjected to tensile tests. With filament contents of 20 to 60 volume percent increases in strength of 200 to 350 percent were achieved, these values approaching the theoretical values. In dynamic tests on specimens reinforced with 20 volume percent the strength values measured after  $2 \times 10^6$  to the seventh power load cycles were 50 percent higher than those of the unreinforced material.

Author

**N72-12502#** Atomic Weapons Research Establishment, Farnborough (England).

**STRENGTHENING OF ALUMINUM BY EXPLOSIVE INCORPORATION OF BERYLLIUM WIRES**

C. V. Jarvis and P. M. B. Slate. In AGARD Composite Mater. Sep 1971. 19 p. refs. (See N72-12492 03 18)

Avail. NTIS

It is shown that beryllium reinforced aluminum can be prepared using an explosive bonding technique. The mechanical properties of such a composite compare well with those from samples prepared by diffusion bonding.

Author

**N72-12503#** Groupe Pechiney, Voreppe (France). Groupe Pechiney.

**PRODUCTION OF ALUMINUM BERYLLIUM COMPOSITES BY HOT PRESSING [REALISATION DE COMPOSITES ALUMINUM BERYLLIUM PAR PRESSAGE A CHAUD]**

R. Cousserans. In AGARD Composite Mater. Sep 1971. 6 p. In FRENCH. (See N72-12492 03 18)

Avail. NTIS

Hot pressing of beryllium fibers or strips into an aluminum beryllium composite by a semi continuous method produced specimens of large dimensions depending on the pressure loads used. A combination hot pressing laminating procedure produced some difficulties because the fragility of the beryllium and the very important elastic separation between the beryllium and the aluminum alloys caused by the reduction rate necessary to obtain a good fiber matrix compounds.

Transl. by G.G.

**N72-12504#** Midwest Research Inst., Kansas City, Mo. Center for Applied Research on Materials.

**MECHANISMS OF FATIGUE IN FILAMENT REINFORCED METALS**

J. R. Harbeck. In AGARD Composite Mater. Sep 1971. 21 p. refs. Sponsored in part by AFML. (See N72-12492 03 18)

Avail. NTIS

The mechanisms of low cycle fatigue were studied in composites of aluminum reinforced with 34 vol % of continuous beryllium filaments. Two series of composite specimens were tested, one series fabricated using as-drawn (rough surfaces) beryllium wire and another using electropolished (smooth surfaces) beryllium wire, to determine the effects of mechanical interlock at the filament-matrix interface on fatigue performance. Axial, strain-controlled fatigue tests were performed. The cyclic stress-strain curves were identical for the two series of composite specimens while composites reinforced with as-drawn filaments exhibited longer fatigue lives than composites reinforced with electropolished filaments. This difference in fatigue lives between the two series of composites was attributed to the difference in the rate of crack growth parallel to filament-matrix interfaces. It was concluded that rough filament surfaces impede interfacial crack growth.

Author

**N72-12505#** Rubber and Plastics Research Association of Great Britain, Shrewsbury (England).

**A NEW TEST FOR THE GLASS-TO-RESIN BOND LIFE IN GRP. COMPARISON OF TYPICAL SYSTEMS EXPOSED TO WATER**

M. H. Stone. In AGARD Composite Mater. Sep 1971. 12 p. refs. (See N72-12492 03 18)

Avail. NTIS

A new method is described for determining the life of the glass to resin bond in GRP exposed to water. The electrical conductance along the strands is measured as a function of time of exposure, and the bond life defined as the time taken for the conductance to attain a certain value. A comparison of several glass coupling agent combinations in epoxy resin exposed to boiling water showed a 7 fold range of bond life, with the S-glass HTS treatment combination giving the most durable bond. Relative bond lives at 60 and 100 C for an E-glass epoxy composite gave an overall activation energy of about 30 Kcal/mole for the debonding process.

Author

**N72-12506#** Institut de Recherches de Chimie Avancee, Paris (France).

**WETTING AND TREATMENT OF REINFORCING FIBER FILAMENTS FOR ORGANIC MATERIALS [MOUILLAGE ET TRAITEMENT DES RENFORCEMENTS FILAMENTAIRES ASSOCIES A DES MATIERES ORGANIQUES]**

G. Mavel. In AGARD Composite Mater. Sep 1971. 9 p. refs. In FRENCH. ENGLISH summary. (See N72-12492 03 18)

Avail. NTIS

A technique for measuring the wetting of a monofilament by the resin itself in a temperature range permissible for the later and all along the hardening process is described. Some insight regarding the preimpregnation mechanism and some characterization of the filament rigidity is provided. Typical results are described for various reinforcements.

Author

**N72-12507#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France).

**STUDY OF INTERACTION BETWEEN A BERYLLIUM FIBER AND AN ALUMINUM MATRIX [ETUDE DE L'INTERACTION ENTRE UN FIL DE BERYLLIUM ET UNE MATRICE ALUMINIUM]**

J. P. Tottier and R. Grais. In AGARD Composite Mater. Sep 1971. 9 p. refs. In FRENCH. ENGLISH summary. (See N72-12492 03 18)

Avail. NTIS

Nickel plated beryllium wires have been covered by an electrolytic aluminum coating, with or without formerly removing the nickel layer. Diffusion phenomena have been studied by X-ray diffraction, scanning microscope examination and microprobe analysis, after a series of thermal treatments of variable duration at 250 deg, 480 deg and 600 C. The recrystallization state of the wires and the matrix has been observed by X rays. The sample structure does not undergo any noticeable modification at 250 C or for short treatments at 480 C.

Author

N72-12408# Institut Supérieur des Matériaux et de la Construction Mécanique, Saint-Ouen (France) Lab d'Automatique et de Mécanique Vibratoire

**CALCULATING AND PREDICTING VISCOELASTIC CONSTANTS OF COMPOSITE MATERIALS [SUR LES CALCULS ET LES PREVISIONS DES CONSTANTES VISCOELASTIQUES DES MATERIAUX COMPOSITES]**

N 2 VinhTuong In AGARD Composite Mater Sep 1971 28 p refs In FRENCH, ENGLISH summary (See N72-12492 G3-18)

Avail NTIS

The theory of elasticity is used in conjunction with the Airy stress function to determine elastic constants of unidirectional fiber reinforced composites by computer programs. In elastodynamics, dispersion relations for the propagation of elastic long waves yield elastic constants in various symmetries. In viscoelasticity, upper and lower bounds are obtained separately.

Author

N72-29589# Advisory Group for Aerospace Research and Development, Paris (France)

**COMPOSITE MATERIALS**

B Walter Rosen May 1972 125 p refs (AGARD-LS-55) Avail NTIS HC \$8.25

The material reported was assembled to support a lecture series presented in Oslo (Norway), Lyngby (Denmark) and Lisbon (Portugal) in June 1972. The objective of the lectures was to present the modern composites concept, a review of materials for advanced composites (fibers, reinforced plastics, metal matrix composites). Considerations in the application of advanced composites and airframe application are covered. For individual titles, see N72-29590 through N72-29596.

N72-29590 Materials Sciences Corp., Blue Bell, Pa

**DESIGN OF COMPOSITE MATERIALS**

Walter Rosen In AGARD Composite Mat May 1972 22 p refs (For availability see N72-29589 20-18)

Studies of the relationships between the effective properties of fiber composite materials and the mechanical and geometric properties of their constituents are reviewed. The aims of such studies are, first, to provide the ability to analyze the performance of structures utilizing these heterogeneous materials, and second, to provide guidelines for the development of improved materials. The rationale for designing a material to suit the application is described. The feasibility of accomplishing this aim through the use of high stiffness and high strength filamentary materials is discussed. It is emphasized that the design cycle with composites involves many more steps than the equivalent metallic structural design process. The relationship is developed governing the thermomechanical properties of composites. The importance of heterogeneity and anisotropy are treated. Theoretical results are presented for composite elastic moduli, thermal expansion coefficients, thermal conductivities, and specific heats. Results are presented in a form easily usable for parametric study of candidate materials during the preliminary design phase. The status is discussed of the understanding of the tensile, compressive and shear strengths of unidirectional composites. The definition of the mode of failure is emphasized.

Author

N72-29591 Rensselaer Polytechnic Inst., Troy, N.Y. Materials Div

**FIBER AND MATRIX MATERIALS FOR ADVANCED COMPOSITES**

N J DiMarzio In AGARD Composite Mat May 1972 20 p refs (For availability see N72-29589 20-18)

Composite materials provide a solution for the engineering use of high specific strength high specific modulus, but brittle materials. These brittle materials are used as fibrous reinforcement to provide strength and stiffness in the composite. The fundamental principles for selecting the reinforcements are described, as well as the concepts used to form these materials into high strength filament. Detailed information on the preparation, structure and properties of boron, carbon and organic filament are presented.

Matrix materials, which are used to transfer stress to the fiber and also prevent brittle failure, are discussed in less detail. The techniques for combining filaments and matrix into prepreg or other preforms and the fabrication into structure are considered. Finally, the mechanical properties of composites based on boron, carbon, and organic fibers are presented.

Author

N72-29592 General Dynamics, Fort Worth, Tex

**COMPOSITES IN THE STRUCTURAL DESIGN PROCESS**

M E Waddoups In AGARD Composite Mat May 1972 13 p refs (For availability see N72-29589 20-18)

The use of advanced composites as a primary structural material for aircraft structures has required alteration of the characterization and design process. Specific departures from conventional lightweight metal design practices have resulted because of the fabrication and process control characteristics, the failure characteristics of the material, and the additional structural design variables. Each of these subject areas with the attendant impact of composite materials on design practice are reviewed. Case examples for actual prototype hardware are presented.

Author

N72-29593 National Physical Lab., Teddington (England) Div of Materials Applications

**EXPERIMENTAL METHODS FOR COMPOSITE MATERIALS**

B E Read and G D Dean In AGARD Composite Mat May 1972 28 p refs (For availability see N72-29589 20-18)

A wide range of techniques is discussed for measuring the elastic, viscoelastic, ultimate strength, thermal and electrical properties of fiber reinforced composites. Main emphasis is given to the determination of the basic properties of unidirectionally reinforced composites and for this purpose, the mechanical test samples considered are mainly in the form of rectangular bars. However, some consideration is given to methods involving honeycomb sandwich structures, circular rods, plates, rings and cylinders. For determining the static Young's moduli and Poisson's ratios (tensile and compressive tests) are considered in addition to flexure methods (cantilever, 3-point and 4-point) and also the honeycomb sandwich technique. Methods for measuring the shear moduli include both torsion and off-axis tensile tests. Comparative elastic data obtained by these methods are collected and discussed for unidirectional silica fiber-epoxy, carbon fiber-epoxy, boron fiber-epoxy and boron fiber-aluminum composites. Creep and stress relaxation methods are outlined for studying time dependent viscoelastic behaviour and results illustrated for nylon-rubber and boron-epoxy composites. Several dynamic tests are described including the low frequency forced nonresonance torsion pendulum, audiofrequency resonance and ultrasonic pulse techniques. Dynamic elastic constants and damping factors are illustrated for carbon fiber-epoxy composites as a function of frequency and fiber volume fraction. Methods are assessed for determining the tensile, compressive, flexural and shear strength, fracture energy and fatigue life, and selected data are illustrated for some carbon fiber, boron fiber and glass fiber composites. Techniques for measuring the thermal expansion coefficient, thermal conductivity, heat capacity, electrical resistivity, dielectric constant and loss are outlined and some results presented for unidirectional carbon fiber composites. Brief mention is made of magnetoresistive and thermomagnetic data obtained on a composite formed by the unidirectional solidification of an eutectic InSb-NiSb mixture.

Author

N72-29594 General Dynamics, Fort Worth, Tex

**AUTOMATED DESIGN AND FUTURE DESIGN TRENDS**

M E Waddoups In AGARD Composite Mat May 1972 10 p refs (For availability see N72-29589 20-18)

Examples of the new class of key composites related optimization problems are presented accompanied by illustrations of the application of modern optimization methods to composite design problems.

Author

N72 29595 British Aircraft Corp. Warton (England) Military Aircraft Div.

# **GENERAL CONSIDERATIONS IN THE APPLICATIONS OF ADVANCED COMPOSITES**

I. C. Taig. In AGARD Composite Mat. May 1972. 14 p. refs. (For availability see N72 29589 20 18.)

The characteristics of advanced composites are compared with those of conventional airframe materials. It is shown that many considerations other than conventional mechanical properties and fabrication technology influence the selection and realization of effective applications of composites. Particular attention is given to the assessment of cost effectiveness in the achievement of integrity in a broad sense including protection against adverse environmental effects and to some practical aspects of productivity. Trends in material and manufacturing costs are presented to show that in the airframe industry most parts of the structure could benefit from the extensive use of composites in the next ten years. Expansion and redirection of the research and development effort will be needed to exploit the economic potential of the materials. Author

N72 29596 British Aircraft Corp. Warton (England) Military Aircraft Div.

# **AIRFRAME APPLICATIONS OF ADVANCED COMPOSITES**

I. C. Taig. In AGARD Composite Mat. May 1972. 12 p. refs. (For availability see N72 29589 20 18.)

A wide variety of primary and secondary structural applications of advanced composites are presented. It illustrates using actual or projected examples the progressive introduction into service of components of increasing complexity and cost effectiveness. All previously unpublished information relates to carbon fiber epoxy composites under development in the U.K. but to broaden the picture the coverage also includes boron epoxy carbon epoxy and to a lesser extent boron aluminum applications in the U.S.A. The range of components covered includes composite reinforced metal members sandwich panel structures such as doors floors and control surfaces and the tube members box structures such as tail surfaces and wings frames bulkheads and fuselage shell structures. Particular emphasis is given to the design principles and practical features embodied in each application illustrating as far as possible the general considerations of the previous paper. Where information is available mass savings and cost effectiveness data are quoted and comments on the operating environment and experience in service are included. Author

N73 27474# Advisory Group for Aerospace Research and Development Paris (France)

# **IMPACT OF COMPOSITE MATERIALS ON AEROSPACE VEHICLES AND PROPULSION SYSTEMS**

May 1973. 288 p. refs. In ENGLISH and partly in FRENCH. Presented at Joint Symp. of the AGARD Structures and Mater. Panel and Propulsion and Energetics Panel. Toulouse 20-22 Sep. 1972.

(AGARD CP 112) Avail. NTIS HC \$16.50

The proceedings of a conference on the use of composite materials in the construction of aerospace vehicles and propulsion systems are presented. The subjects discussed include the following: (1) mechanical properties of high performance plastic composites; (2) design concepts using composites in airframes; (3) design and manufacturing aspects of composite materials with organic matrices; (4) application of advanced fibrous composites to aeronautical gas turbine engines; and (5) failure analysis of fiber reinforced composite motor case.

N73 27475 Air Force Materials Lab. Wright-Patterson AFB Ohio Nonmetallic Materials Div.

# **MECHANICAL PROPERTIES OF HIGH PERFORMANCE PLASTIC COMPOSITES**

Theodore J. Reinhart, Jr. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 27 p. refs. (For availability see N73 27474 18 18.)

Data and information are presented on high strength high modulus reinforcing fibers and organic resin composites

fabricated from these fibers. Glass boron graphite various metallic PRD 49-III and silicon carbide fiber and composite properties are discussed. Combined fiber or hybrid composites containing boron and S-glass and beryllium fibers and S-glass are discussed. The properties of the various forms of asbestos reinforcements are presented along with the mechanical properties of several asbestos reinforced epoxy-resin composites. Fatigue creep and stress rupture data are presented where data on similar composite constructions could be found in the literature. Author

N73 27476 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt Stuttgart (West Germany) Inst. fuer Bauweisen- und Konstruktionsforschung

# **FIBER REINFORCED MATERIALS FOR APPLICATION IN THE COLD PART OF TURBINE ENGINES**

Gerhard Grueninger and Richard Kochendoerfer. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 13 p. refs. (For availability see N73 27474 18 18.)

The strength to density ratio property of fiber reinforced materials with plastic and metallic matrix is discussed. The properties of fibrous materials used in structures which are submitted to uniaxial loads are analyzed. The use of composite materials for blades and discs of turbine engines for operation at elevated temperatures is analyzed. Author

N73 27477 Hawker Siddeley Aviation Ltd. Woodford (England)

# **CARBON FIBRE COMPOSITES PROMISES AND PROBLEMS**

W. G. Heath. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 11 p. refs. (For availability see N73 27474 18 18.)

Structures of carbon fiber composite show great promise in reduction of weight and freedom from fatigue and corrosion. They also permit the designer to tailor the material to match the applied loading. There are on the other hand serious problems to be overcome: the high cost of the material its brittle nature its susceptibility to erosion and its lack of robustness the variability between apparently identical components and the difficulty of making joints between sub-assemblies. This paper examines the promises and problems in turn it shows how the promising features might be exploited more fully and seeks solutions to the problems. Author

N73 27478 Naples Univ. (Italy)

# **PRODUCTION OF FIBROUS METAL COMPOSITES BY POWDER ROLLING**

I. Crivelli Visconti P. Jauch (Aeritalia Naples) and C. Voto (Aeritalia Naples). In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 23 p. refs. (For availability see N73 27474 18 18.)

The fundamental aspects of powder rolling are considered regarding both the production of continuous strips starting from metal powder and the production of fibrous metal composites obtained by contemporary rolling of powder with strong reinforcing wires. The method can be applied to a large number of matrix fibers systems of aeronautical interest. After a description of the influence of each parameter regulating the physical properties of the green strip like roll gap feeding system type and size of powder roll diameter number of fibers some of theoretical and experimental properties of systems of practical interest are reported. From the results obtained during the entire work on the described method the actual potential and advantages of this method of metal composites fabrication is discussed in relation to other similar methods and a few examples of possible applications are given. Author

N73 27479 British Aircraft Corp. Preston (England) Military Aircraft Div.

# **DESIGN CONCEPTS FOR THE USE OF COMPOSITES IN AIRFRAMES**

I. C. Taig. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 18 p. refs. (For availability see N73 27474 18 18.)

A philosophy for design of filamentary composite components

emphasizing integrity and cost effectiveness is outlined. This involves intensive development of a limited number of basic structural concepts. Several such concepts, applicable to airframe structures, are reviewed starting with a simplified assessment of their structural efficiency (measured in terms of mass saving, and including a brief discussion of features relating to integrity and fabrication. The review includes composite reinforcement of metal structures, solid rods, tubes and beams, sandwich skin panels and sandwich box structures, stiffened skins and wound tubes and lattices. Particular attention is given to attachments and load introduction and a brief section deals with bonded and mechanical joints. The paper concludes with illustrations of structures embodying some of the concepts described. Author

**N73-27480** Air Force Flight Dynamics Lab. Wright Patterson AFB, Ohio.  
**DESIGN AND FAILURE CRITERIA OF ADVANCED COMPOSITE PRIMARY STRUCTURE**

Larry G. Kelly. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 8 p. (For availability see N73-27474 18-18)

The design, fabrication, and flight test of a boron/epoxy F-111 stabilizer are discussed. The applicability of this composite material to airframe construction and the ability to achieve significant weight savings are reported. The material allowables and design philosophy utilized in the evolution of this structure are employed as an example of an approach to establishing logical failure criteria from which efficient designs can be developed with continuous aligned high modulus high strength composite materials. One of the outstanding features of filamentary composite materials is their directional properties which provides the ability through crossplying of lamina to tailor a structure which meets specific loads and/or stiffness requirements with a minimum amount to material and weight. Thus a more efficient and reliable method of establishing design allowables for all laminates of interest was developed. The approach selected was to experimentally determine the stress-strain response to simple unidirectional laminae at the required design temperature and with the aid of a mathematical model establish a failure envelope to serve as the designers tool for selection of a suitable laminate thickness and ply orientation for a given set of load conditions. Author

**N73-27481** Stuttgart Univ. (West Germany).  
**PRESENT AND FUTURE POSSIBILITIES OF HIGH STRENGTH AND STIFFNESS-TO-WEIGHT RATIO COMPOSITES IN PRIMARY STRUCTURES**

Ulrich Huetter. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 14 p. refs. Prepared in cooperation with DFVLR, Stuttgart. (For availability see N73-27474 18-18)

The application of composite materials to primary aircraft and spacecraft structures is discussed. Some of the limitations which affect the use of the composite materials for certain purposes are described. The mechanical and physical properties of shell structures are reported. A hypothesis for composite material failure is developed. Charts, graphs and diagrams are included to clarify the theoretical concepts. Author

**N73-27482** Messerschmitt Bolkow Blohm GmbH, Ottobrunn (West Germany).  
**APPLICATION OF COMPOSITE MATERIALS FOR AEROSPACE STRUCTURES**

F. Och and W. Jonda. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 10 p. refs. (For availability see N73-27474 18-18)

The use of reinforced composite materials for aerospace structures is discussed. Component developments for the application of various composites, such as glass, carbon, and PRD, as well as combinations of glass and carbon are reviewed. An example of an all-glass composite used in a third stage of a rocket launcher is presented. The application of all-carbon composites for helicopter rotor blades is reported. The mechanical and physical properties of PRD-49 organic fiber are analyzed. Author

**N73-27483** Westland Helicopters Ltd., Hayes (England).  
**USE OF COMPOSITES IN HELICOPTERS. ADVANTAGES AND DISADVANTAGES**

H. F. Winny. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 9 p. refs. (For availability see N73-27474 18-18)

A survey is given of the use of glass and carbon fiber composite materials for helicopter structures. It is reported that glass-reinforced plastics should be used on rotorheads of the semi-rigid types and on rotor blades where fatigue strength and low stiffness and density are required to save weight. Carbon fiber reinforced plastics are recommended for the main helicopter structures. A summary of the strength and stiffness properties of both types of composites is presented. Methods of overall fabrication for cost-effective materials are proposed. Author

**N73-27484** Societe Nationale Industrielle Aerospatiale, Courbevoie (France). Dept. Structures Nouvelles.  
**COMPOSITES IN ENGINE STRUCTURES AND THEIR ADAPTATION TO AERONAUTICAL NEEDS (LES COMPOSITES DANS LES STRUCTURES D'ENGINS ET LEUR ADAPTATION AUX BESOINS AERONAUTIQUES)**

G. Jube. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 10 p. In FRENCH. (For availability see N73-27474 18-18)

The use of highly rigid composite materials in aircraft structures, particularly engine structures is examined. A detailed review was made of the use of reinforced boron and carbon filaments. A comparison was also made of the fatigue life of the two materials. Transl. by E. H. W.

**N73-27485\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.  
**APPLICATION OF COMPOSITES TO THE SELECTIVE REINFORCEMENT OF METALLIC AEROSPACE STRUCTURES**

W. A. Brooks Jr., E. E. Mathauser, and R. A. Pride. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 15 p. refs. (For availability see N73-27474 18-18)

CSCL 11D

The use of composite materials to selectively reinforce metallic structures provides a low cost way to reduce weight and a means of minimizing the risks usually associated with the introduction of new materials. An overview is presented of the NASA Langley Research Center programs to identify the advantages and to develop the potential of the selective reinforcement approach to the use of composites. These programs have shown that selective reinforcement provides excellent strength and stiffness improvements to metallic structures. Significant weight savings can be obtained in a cost-effective manner. Flight service programs which have been initiated to validate further the merits of selective reinforcement are described. Author

**N73-27486** Technische Universität Brunswick (West Germany). Inst. fuer Flugzeugbau und Leichtbau.  
**EXPERIENCE WITH COMPOSITES AS OBTAINED FROM GLIDERS**

W. F. Thielemann. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 7 p. (For availability see N73-27474 18-18)

A survey is given of the design and manufacture of gliders using glass fiber and carbon fiber reinforced plastic composites for primary structures. The two main advantages cited are: (1) the possibility of getting very smooth surfaces of high aerodynamic quality and (2) the possibility of reducing the fabrication costs by producing large integral structures instead of assembling many prefabricated metallic structural details. The design problems, structural problems, and performance test data for reinforced plastic construction are reported. Author

**N73-27487** Army Air Mobility Research and Development Lab., Fort Eustis, Va. Structures Div  
**ADVANCES IN BALLISTICALLY TOLERANT FLIGHT CONTROLS**

I. E. Figue Sr. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 8 p. refs. (For availability see N73-27474 18-18)

Combat data indicate that helicopter flight control components are exceptionally vulnerable to catastrophic failure upon ballistic impact. The ballistic tolerance approach, which is to design the critical components to function after ballistic penetration, offers a solution to reduce vulnerability. Studies have shown that this approach can virtually eliminate catastrophic failure while achieving substantial weight saving and reduced production costs. Limited data indicate this approach is also adaptable to flight control bearings and attachments. Venting was found to reduce the damage on the exit side of sandwich structures and prestriking was found to prevent delamination of the exit face in the area of impact. Author

**N73-27488** Royal Aircraft Establishment, Farnborough (England) Structures Dept.  
**INSTABILITY OF LAMINATED COMPOSITE PLATES**

G. Z. Harris. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 19 p. refs. (For availability see N73-27474 18-18)

The response of general laminated plates to applied loading exhibits a coupling between bending and extensional modes of deformation. Such a laminate will, for example, undergo a bending response when load is applied in the plane of the laminate. Such coupling may be significant when shear or compressive loads are applied in-plane, since the additional deformation modes may reduce the buckling load or affect the post-buckling stiffness of the laminate. The present paper considers the stiffness immediately after buckling of two types of panel which undergo bifurcational buckling. The first class of panel considered is one of angle-ply type. A solution is derived for the initial buckling of a rectangular panel to which is applied a constant end displacement. The pre-buckling response is one which exhibits no out of plane displacements, although the initial buckling load is affected by the existence of out of plane coupling. The second class of panel is of cross-ply type, the buckling loads being derived for a long panel having a constant strain edge member and subjected to end load. Author

**N73-27489** Royal Netherlands Aircraft Factories, Fokker Schiphol-Oost  
**DESIGN AND MANUFACTURING ASPECTS OF COMPOSITE MATERIALS WITH ORGANIC MATRICES FOR APPLICATION AT HIGH TEMPERATURES**

J. J. Cools. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 15 p. refs. (For availability see N73-27474 18-18)

Some design and manufacturing aspects are presented of the mixed structure concept which was developed for application in aerospace structures subjected to high temperatures. In this concept a HM-composite material with an organic matrix is laminated between metallic faces to combine simultaneously the favorable features of both types of materials. The HM-composite material is the main load-carrying component. The metallic faces protect the organic matrix against oxidation by air at high temperatures, provide an electrically conductive surface of the structure and contribute to stabilization against buckling. The mixed structure concept can also be applied to aerospace structures subjected to normal operating temperatures. Author

**N73-27490** National Gas Turbine Establishment, Pyestock (England)  
**A LIMITED REVIEW OF THE APPLICATION OF ADVANCED FIBROUS COMPOSITES TO AERO GAS TURBINE ENGINES**

A. W. H. Morris. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 16 p. refs. (For availability see N73-27474 18-18)

CSCL 11D

A review of fiber reinforced composite material relevant to

zero gas turbine engine application is presented for systems both commercially available and projected. Emphasis has been placed on those mechanical property requirements and fabrication problems which are peculiar to gas stream components. Although high strength and high elastic modulus composites are available in organic and inorganic matrices for low temperature application, these materials exhibit extremely poor impact and erosion characteristics which may limit use where foreign object damage is prevalent. Several engineering solutions to the problem are discussed. The application of composites in the high temperature turbine stage has difficulties such as fiber stability and thermal fatigue and is considered to be very impractical. The development of directionally solidified eutectics, which can loosely be described as composites, offers more encouragement as the next generation turbine material. Author

**N73-27491\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio  
**MATERIAL AND STRUCTURAL STUDIES OF METAL AND POLYMER MATRIX COMPOSITES**

Robert A. Signorelli, Tito T. Serafini, and Robert H. Johns. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 16 p. refs. (For availability, see N73-27474 18-18)

Fiber reinforced composites and design analysis methods for these materials are being developed because of the vast potential of composites for decreasing weight and/or increasing use temperature capability in aerospace systems. These composites have potential for use in airbreathing engine components as well as aeronautical and space vehicle structures. Refractory wire-superalloy composites for use up to 2200 F or more and metal matrix composites for lower temperature applications such as aerospace structures and turbojet fan and compressor blades are under investigation and are discussed. The development of a number of resin systems, including the polyimides and polyphenyleneoxalines, is described and their potential for use at temperatures approaching 315 C (600 F) is indicated. Various molecular modifications that improve processability and/or increase thermal and oxidative resistance of the resins are also described. Structural analysis methods are discussed for determining the stresses and deformations in complex composite systems. Consideration is also given to residual stresses resulting from the curing process and to the foreign object damage problem in fan blade applications. Author

**N73-27492** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)  
**ELABORATION OF REFRACTORY COMPOSITE MATERIALS BY DIRECTIONAL SOLIDIFICATION (ELABORATION DE MATERIAUX COMPOSITES REFRACTAIRES PAR SOLIDIFICATION ORIENTEE)**

Maurice ElGammal. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 10 p. refs. In FRENCH-ENGLISH summary. (For availability see N73-27474 18-18)

The principles of directional solidification for producing lamellar and fibrous composite materials from eutectic alloys are discussed. Some pseudo binary eutectics and more complex alloys are compared for high mechanical strength at elevated temperatures. The properties of these materials are outlined in order to determine the use for turbine blades and vanes. Problems involved in the application of the composite materials are presented. Author

**N73-27493** General Electric Co., Cincinnati, Ohio  
**DIRECTIONALLY SOLIDIFIED EUTECTICS IN GAS TURBINE DESIGN**

L. P. Jahnke, H. J. Brands, and G. D. Oxx, Jr. In AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems. May 1973. 9 p. refs. (For availability see N73-27474 18-18)

Composite structures consisting of high strength fibers or plates in ductile matrices with outstanding high temperature properties are achievable in directionally solidified eutectics. This new class of materials represents a major innovation in gas turbine blade technology. The advantages and limitations of the



two more promising eutectics systems and the relationship of these properties to turbine blade design is discussed. Innovations in design and further property improvements will be required to successfully exploit these materials in engine hardware. It is concluded that the payoff offered by this technology fully justifies a major investment of resources to achieve a practical system.

Author

**N73-27494** Motoren- und Turbinen-Union Muenchen G m b H (West Germany)

**EUTECTIC ALLOYS WITH UNI-DIRECTIONAL SOLIDIFICATION. STUDY ON THEIR USE FOR TURBINE BLADES**

c17

H. Huff and W. Betz. In AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems. May 1973. 6 p. refs. (For availability see N73-27474 18-18)

The principle of directional solidification of eutectic alloys is briefly shown and the influence of temperature gradient, solidification rate and impurities is described. Using a list of the most important demands on turbine blade materials the merits and demerits of directionally solidified eutectics for this purpose are discussed. It seems that there are good chances for utilizing this compound material for gas turbines. There will be however a lot of further investigations necessary especially with respect to casting technology.

Author

**N73-27495** Rolls Royce, Ltd. Bristol (England). Engine Div. **POTENTIAL USE OF COMPOSITE MATERIALS FOR GAS TURBINE STATIC STRUCTURES**

J. W. Sharp and L. Battezzato (Fiat S.P.A.). In AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems. May 1973. 14 p. refs. (For availability see N73-27474 18-18)

The applications of composite materials on a number of static gas turbine components and assessment of these components have shown that they can be made lighter than their metal design equivalent. Cost savings in some cases could also be expected although some improved manufacturing techniques are necessary. The materials considered are primarily glass and carbon fiber reinforced structures with a working temperature up to 250 C. Experience with such composite structures are reviewed including failures and successes.

Author

**N73-27496** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Corbeil (France)

**APPLICATION OF THE BASE COMPOSITES OF CARBON FIBERS AND BORON WIRE TO COMPRESSOR BLADES [APPLICATION DE COMPOSITES A BASE DE FIBRES OF CARBONE ET DE FILS DE BORE AUX AUBES DE COMPRESSEUR]**

P. Leclercq and R. Chevalier. In AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems. May 1973. 8 p. In FRENCH (For availability see N73-27474 18-18)

A critical summary was made of the fabrication of compressor blades from metallic composites. The mechanical resistance, vibration characteristics, fatigue, and erosion properties of carbon epoxy, boron epoxy, boron aluminum composite blades were examined. Performance tests results are given in tables.

Transl. by E. H. W.

**N73-27497** Air Force Aero Propulsion Lab., Wright Patterson AFB, Ohio

**FATIGUE TOLERANCE OF DAMAGED METAL COMPOSITE BLADING**

T. J. Norbut. In AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems. May 1973. 10 p. refs. (For availability see N73-27474 18-18)

The successful exploitation of the lightweight high specific strength and modulus features of metal matrix composite systems in turbine engine blading rests heavily on the realistic assessment of the materials inherent tolerance to sustain damage from foreign objects ingested into the engine. The spectrum of foreign object debris typically contained in military and commercial engine specifications is summarized to obtain a perspective of the debris characteristics a turbine engine is expected to ingest and reliably tolerate. The scope of these specifications served as the basis

for the development of a damage simulation technique for a specific class of foreign object debris. 403 stainless steel and Ti 6Al-4V blades damaged with this technique were compared to typical field damage blades and found to correlate favorably. The technique was subsequently utilized to damage representative Boron/Aluminum airfoil specimens for evaluation of fatigue strength degradation effects. It was concluded that Boron/Aluminum possessed a considerably lower notch sensitivity in high cycle fatigue when compared to the notched fatigue characteristics of homogeneous blade materials.

Author

**N73-27498** Pratt and Whitney Aircraft, East Hartford, Conn. **BORON-POLYIMIDE REINFORCED TITANIUM FAN DISKS**  
Hans Stargardt and Karl Jakobsen. In AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems. May 1973. 10 p. (For availability see N73-27474 18-18)

The design, fabrication, and testing of boron-polyimide reinforced titanium fan disks having a temperature capability of 600 F are described. The high modulus and low density of this material allow for a redesign of the fan disk with a reduction in weight of 36% compared to the conventional design. Processing techniques involving filament winding and resin curing were developed on 10 inch diameter hoops. Two fullscale disks were fabricated and evaluated through spin testing to 800 F.

Author

**N73-27499** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France). Dept. Resistance des Matériaux

**STUDY OF DISK BINDING OF COMPRESSORS BY BASE COMPOSITES OF BORON WIRE [ETUDE DU FRETTAGE DES DISQUES DE COMPRESSEUR PAR DES COMPOSITES A BASE DE FIL DE BORE]**

Claude Stoltz. In AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems. May 1973. 8 p. In FRENCH (For availability see N73-27474 18-18)

A theoretical study was made of the general principles of binding compressor disks with boron composites. Data cover possible weight reductions and peripheral speed augmentation. Crack and endurance tests are also made. The results are compared with predictions.

Transl. by E. H. W.

**N73-27500** Army Missile Command, Redstone Arsenal, Ala. **FAILURE ANALYSIS OF A FIBER REINFORCED COMPOSITE MOTOR CASE USING DISTORTIONAL ENERGY AND MAXIMUM STRAIN THEORIES OF FAILURE**

Richard J. Thompson, John W. Sofferis, and Charles M. Eldridge. In AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems. May 1973. 3 p. refs. (For availability see N73-27474 18-18)

A method of determining the failure condition of a fiber reinforced composite structure is extended for application to an actual design and analysis problem. The original method uses the distortional energy and maximum strain theories of failure. A finite element stress analysis program was modified for application to fiber composites. This work extends the failure program to include helical tubes. The method of calculation of wrap angle is altered after first stage yielding as pressure increments are increased. Provision was made to automatically update the displacement field. After each loading increment, the displacement field is calculated and the new values are added to the old ones.

Author

## 19 MATHEMATICS

Preceding page blank

215

## 19 MATHEMATICS

Includes calculation methods and theory and numerical analysis. For applications see specific categories. For related information see also 08 Computers.

No abstracts in this subject category

## 20 METEOROLOGY

Includes climatology, weather forecasting, and visibility studies. For related information see also 13 Geophysics and 30 Space Sciences

**N72-11811#** Advisory Group for Aerospace Research and Development, Paris (France)

**A SUMMARY OF ATMOSPHERIC TURBULENCE RECORDED BY NATO AIRCRAFT**

Cyril G. Peckham (Technology, Inc., Dayton, Ohio) Sep 1971 133 p refs

(Contract AGARD-OTAN LMP 67-68)

(AGARD-R-686-71 UDC:651.651.6) Avail NTIS

A summary and analysis of flight-measured cumulative acceleration distributions due to atmospheric turbulence are presented. Data from 37 different aircraft was processed. A description of the recording systems and the methods of data processing is given. The power spectral density methods to derive gust velocities is detailed. Author

**N72-21590#** Advisory Group for Aerospace Research and Development, Paris (France)

**ATMOSPHERIC POLLUTION BY AIRCRAFT ENGINES AND FUELS, A SURVEY**

Robert F. Sawyer (Calif. Univ., Berkeley) Mar 1972 40 p refs (AGA-AR-40) Avail NTIS

A survey of atmospheric pollution by aircraft engines, aircraft fuels, and related research work was conducted among several European nations and the United States. Twenty-seven current or potential problem areas are described. Of these areas, the five most pressing are: (1) engine emission characteristics, (2) test procedures, (3) nitric oxide formation, (4) carbon monoxide and hydrocarbons at low power, and (5) effect of high altitude emissions. It was recommended that research be encouraged in all 27 areas, although in some cases only a better definition of the nature of the problem as opposed to a solution may be required. A selected but extensive bibliography is provided in the appendix. Author

**N74-14271#** Advisory Group for Aerospace Research and Development, Paris (France)

**ATMOSPHERIC POLLUTION BY AIRCRAFT ENGINES**

Sep 1973 405 p refs. Mostly in ENGLISH, partly in FRENCH. Conf. held at London 9-13 Apr 1973

(AGARD CP-125) Avail NTIS HC \$22.25

The proceedings of a conference on the effects of aircraft engines on atmospheric pollution are presented. The impact of military and civilian aircraft operations on pollution levels are compared with the pollution from other sources. The subjects stressed are: (1) effects of pollution at very high altitudes, (2) effects of pollution near airports, and (3) methods for reduction of pollutant production in combustion processes and in engines. A review of the physiological effects of air pollution is included. For individual titles see N74-14272 through N74-14306.

**N74-14272\*** New York Univ., N.Y. Dept. of Aeronautics and Astronautics

**REDUCTION OF NO FORMATIONS BY PREMIXING**

Antonio Ferni. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 10 p ref. (For availability see N74-14271 05 20)

(Grant NGR 33 016 131)

The effects of exhaust gases from supersonic transport aircraft on the equilibrium of the stratosphere are discussed. A method for reducing the amount of nitrogen oxides generated by the engines of supersonic transports is described. The engine requirements for the turbojet engines of the supersonic transport aircraft are defined. The design of combustion chambers to provide premixed flames and the thermodynamic properties of premixed flames are analyzed. Charts are developed to show the isotherms of the ignited mixtures for various conditions and the mass fraction of nitrogen oxide along selected streamlines. Author

**N74-14273** Department of Transportation, Washington, D.C. **UNITED STATES DEPARTMENT OF TRANSPORTATION RESEARCH PROGRAM FOR HIGH ALTITUDE POLLUTION** Alan J. Grobner. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs. (For availability see N74-14271 05 20)

A review of a United States program to provide an assessment by 1974 of the impact on man, plants and animals of climatic changes due to perturbations of the upper atmosphere by the propulsion effluents of a world high altitude aircraft fleet as projected to 1990 is presented. Some physical considerations which must be taken into account in this program are described including representations of the stratosphere in its unperturbed state, of the effluents of vehicles expected in 1990 of the perturbed stratosphere of 1990, of the perturbed troposphere of 1990 and 2020, of the effects of climatic changes on the biosphere and of social and economic measures of these biological effects. Author

**N74-14274** California Univ., Berkeley, Dept. of Chemistry **REACTION OF OZONE WITH NITROGEN OXIDES AT HIGH ALTITUDES**

Harold S. Johnston and Gary Whitten. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs. Sponsored by DOT. (For availability see N74-14271 05 20)

Ozone formation in the stratosphere by the dissociation of oxygen by ultraviolet radiation below 242 nm is discussed. Ozone is removed from the stratosphere by: (1) the reaction of oxygen atoms and ozone, (2) by transport to the troposphere, (3) by catalytic reactions with free radicals based on water and (4) by catalytic reactions with the oxides of nitrogen. The most important factor in the natural removal of stratospheric ozone appears to be catalytic cycles based on the oxides of nitrogen. The natural source strength has been calculated by three different investigators. There is about a factor of four uncertainty in the natural rate of injection of nitric oxide in the stratosphere. There is about a factor of four uncertainty in the calculated rate of introduction of nitric oxide in the stratosphere from full scale operation of supersonic transports of current and past designs. Within these two ranges of uncertainty, 500 supersonic transports would introduce nitric oxide in the stratosphere at a rate comparable to the known natural sources. Author

**N74-14275** Meteorological Office (Gt. Brit.) **NITROGEN OXIDES, NUCLEAR WEAPON TESTING, CONCORDE AND STRATOSPHERIC OZONE**

P. Goldsmith, A. F. Tuck, J. S. Foot, E. L. Simmons, and R. L. Newson. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 15 p refs. (For availability see N74-14271 05 20)

The attenuation of the earth's ozone shield and an increase in the ultraviolet radiation reaching the planetary surface because of aircraft engine exhaust products is examined. It is stated that insufficient investigation has been made of the effects of radiation photochemistry and atmospheric circulation on the ozone content. The introduction of nitrogen oxides into the stratosphere through nuclear tests is compared with the amount expected from aircraft operations. Emphasis is placed on the chemical kinetics of heated air. The chemical processes used in calculating the nitrogen oxide production in the hot air masses created by the nuclear shock wave are analyzed. Author

**N74-14276** Pratt and Whitney Aircraft, East Hartford, Conn. **DETAILED EXHAUST EMISSION MEASUREMENTS OF THREE DIFFERENT TURBOFAN ENGINE DESIGNS**

A. W. Nelson. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs. (For availability see N74-14271 05 20)

A series of test programs was conducted to better define the exhaust emission characteristics of three different aircraft engine models: the JT3D, a low bypass ratio turbofan engine; the JT8D, a mixed flow turbofan engine; and the JT9D, a high bypass ratio turbofan engine. Special investigations were conducted on the JT3D and JT9D engines to investigate inlet temperature and humidity effects. Analysis of these data was supplemented with previously obtained data in order to increase the range of variables investigated for the mixed flow JT8D.

engine special tests were conducted using an engine especially modified to physically separate the fan and core engine streams so that true undiluted emission measurements could be obtained. Three different methods were used to evaluate the emission levels of each engine model: multipoint rake, exhaust case pressure probes and super detailed traversing. Analysis of the latter method produced highly refined contour plots of CO, T<sub>4</sub>C and NO<sub>x</sub> emission footprints as well as exhaust temperature and pressure variations at the plane of the tailpipe. The average emission levels obtained by each of the three measurement methods are compared. Author

**N74-14277** Bonn Univ. (West Germany) Inst fuer Physikalische Chemie

**PHOTO-OXIDATION OF AIRCRAFT ENGINE EMISSIONS AT LOW AND HIGH ALTITUDES**

K. H. Becker and U. Schurath. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 9 p. refs. (For availability see N74-14271 05 20)

The mechanism of photochemical smog formation is examined. The applicability of photochemical smog formation to aircraft emissions is described. It is concluded that photo oxidation mechanisms of pollutants from aircraft and other sources in the troposphere undergo fundamental changes with altitude: radical and atom reactions and probably reactions of metastable oxygen molecules becoming more important in the colder regions of the troposphere. Serious contamination of the troposphere by aircraft is not expected, because the residence time of pollutants is short compared with emissions rates. Author

**N74-14278** Oslo Univ. (Norway) Inst of Geophysics  
**EFFECT OF SUPERSONIC TRANSPORT UPON THE OZONE LAYER, STUDIED IN A TWO-DIMENSIONAL PHOTOCHEMICAL MODEL WITH TRANSPORT**

Eigh. Hestvedt. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 8 p. refs. (For availability see N74-14271 05 20)

A steady state two-dimensional model of the stratospheric ozone layer is presented. Photochemical reactions involving oxygen, hydrogen, and nitrogen are considered along with the effect of a parameterized two dimensional transport, by mean motion and by eddies. A parameterized meridional distribution of NO<sub>x</sub> is applied, computed from one dimensional models. The model is in fair agreement with observed ozone data. The reduction of ozone from emission of NO<sub>x</sub> from supersonic aircraft is studied, assuming a fleet of 200 aircraft flying at given altitudes and uniformly distributed over the globe. The effect is found to depend critically upon the flight level. For mid latitude, summer, the ozone column density is reduced by 0.4% for a flight level of 18 km. For flight levels 23 km and 28 km the reduction is 1.6% and 2.3% respectively. Accordingly, the increase in UV radiation amounts to approximately 0.8%, 3.2% and 4.6% for the same flight levels. Author

**N74-14279** Institut d'Aeronomie Spatiale de Belgique, Brussels

**CHEMICAL KINETIC IN THE STRATOSPHERE**

G. Brasseur. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 13 p. refs. (For availability see N74-14271 05 20)

The production of ozone in the stratosphere by photodissociation of molecular oxygen is discussed. The specific chemical reactions are analyzed to identify the components involved and the reaction kinetics for various regions of the atmosphere. It is concluded that hydrogen compounds play a significant role in the formation of nitric acid and atmospheric chemical reactions must account for the formation and destruction of hydroxyl and hydroperoxyl radicals. Author

**N74-14280** Deutsche Forschungs und Versuchsanstalt fuer Luft und Raumfahrt, Stuttgart (West Germany) Inst fuer Reaktionskinetik

**A NEW ANALYTICAL TECHNIQUE FOR CONTINUOUS NO DETECTION IN THE RANGE FROM 0.1 TO 5000 PPM**

H. Meinel and Th. Just. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 5 p. refs. (For availability see N74-14271 05 20)

An analytical technique for the continuous detection of small amounts of nitrogen oxide is described. The process is applied to analyzing the amount of nitrogen oxides in engine exhaust gases. A schematic diagram of the ultraviolet resonance absorption nitrogen oxide detector is provided. It is stated that in terms of sensitivity the new method is superior to conventional continuum absorption techniques in the ultraviolet and infrared regions by a factor of ten to thirty. Author

**N74-14281** Bristol Univ. (England) Dept of Aeronautical Engineering

**PROBLEMS OF CHEMICAL POLLUTION BY AIRCRAFT. THE AIRPORT AND ITS IMMEDIATE ENVIRONMENT**

T. V. Lawson. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 3 p. (For availability see N74-14271 05 20)

The chemical pollution of the airport and its environment is discussed. It calls for a careful study of all surveys so that the built implications of the model are obvious and it concludes that the problems of chemical pollution by the aircraft themselves are small. It suggests that much more progress will be made in attempts to reduce pollution around airports by concentrating upon organizations other than the engine manufacturers. It closes by suggesting that authors of technical papers be encouraged to supply an epilogue in which they summarize the findings of their work for the benefit of the lay public. Author

**N74-14282** Warren Spring Lab, Stevenage (England) Air Pollution Div

**RELATIVE AIR POLLUTION EMISSIONS FROM AIRCRAFT IN THE UK AND NEIGHBOURING URBAN AREAS**

A. W. C. Keddie, J. Parker and G. H. Roberts. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 9 p. refs. (For availability see N74-14271 05 20)

Air pollution levels at Stansted Airport in relation to emissions from four nearby towns are discussed. Calculations have been made of pollution emissions from these four sources and also from the airport and the expected contributions from these sources at three local sites have been examined. These values are compared with actual measurements at the three sites. Author

**N74-14283** Chemical Defence Experimental Establishment, Porton (England)

**GROUND CONTAMINATION BY FUEL JETTISONED FROM AIRCRAFT**

N. L. Cross and R. G. Picknett. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 9 p. refs. (For availability see N74-14271 05 20)

A study of the problem of ground pollution produced by fuel jettisoned from aircraft under emergency conditions was conducted. The likely size distribution of drops released when fuel is jettisoned is examined. The proportions of jettisoned fuel which survive evaporation to reach the ground are determined. It is stated that the contamination density on the ground depends on atmospheric stability, wind speed, and direction of flight relative to wind direction. Data obtained from flight tests of jettisoned fuel are presented in tables and graphs. Author

**N74-14284** Air Corporations Joint Medical Service (BEA/BOAC), London (England)

**POLLUTION LEVELS AT LONDON (HEATHROW) AIRPORT AND METHODS FOR REDUCING THEM**

D. M. Bruton. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 6 p. ref. (For availability see N74-14271 05 20)

Exhaust pollution levels at Heathrow Airport, London, England were conducted. Medical surveys of the interior of buildings were conducted to determine pollution levels. It was determined that pollution levels are below those of many urban areas and do not appear to represent either a short or long range hazard to health. Local pollution problems constitute a source of annoyance to ground personnel employed at the airport. Methods for reducing the exhaust fume emission by vehicle selection, engine tuning and maintenance practices are recommended. Author

**N74-14285** Naval Postgraduate School, Monterey, Calif. Dept. of Aeronautics

**POLLUTION CONTROL OF AIRPORT ENGINE TEST FACILITIES**

D. L. Bailey, P. W. Tower, and A. E. Fuhs. *In* AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 32 p. refs. (For availability see N74-14271 05-20)

Engine test facilities are required to meet the same environmental standards as any other industrial facility. To meet the standards for smoke, noise, gaseous pollutants, etc., control equipment must be installed. Due to large mass flow rates, the control equipment is expensive; careful attention to design is necessary to control costs. Pollution control forces new constraints on exhaust stack temperature, flow uniformity, and pressure. Conversely, installation of pollution abatement apparatus may cause adverse operating conditions such as distorted flow into the engine and wrong augmentation ratio. The internal aerodynamics of engine test cells must be mastered to a level not possible previously. Scale models of test cells were fabricated in modules so that some 750 different combinations could be tested. Distortion at the engine face was measured and correlated in terms of component factors. Augmentation ratio and cell depression were measured. An analytical model correctly predicted the measured quantities except for distance from engine nozzle to augmentor inlet. With the data accumulated it should be possible to match pollution control requirements to test cell parameters. Author

**N74-14286** Motoren- und Turbinen-Union Muenchen GmbH (West Germany). Engine Development and Testing Dept.

**EXHAUST EMISSION MEASUREMENTS ON THE GE T64-7 TURBOPROP ENGINE**

W. Bergt, G. Kappler, and G. Meikis. *In* AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 4 p. refs. (For availability see N74-14271 05-20)

Exhaust emission measurements have been carried out on the engine GE T64-7 with the objective to determine qualitatively the mass emission of the pollutants carbon monoxide, unburnt hydrocarbons, and oxides of nitrogen at different power ratings. Although for aircraft engine application the operating modes were just recently issued in the EPA proposed standards for control of air pollution, the engine was run through a 13-point California Test Cycle as applicable to Diesel engines for vehicles up to 6000 lb gross weight. The numerical evaluation of the measured exhaust emissions was carried out using the method of analysis established for the above mentioned test cycle. The measurements were taken for three different types of fuel: JP4, Diesel at 20°C and Diesel at 50°C. The exhaust gas sampling using heated sampling lines and the analytical system set up for the measurements were in agreement with SAE Specifications. The instruments used in the analytical system are shown. Author

**N74-14287** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Reaktionskinetik

**NO FORMATION IN FUEL RICH FLAMES. A STUDY OF THE INFLUENCE OF THE HYDROCARBON STRUCTURE**

K. H. Eberius and Th. Just. *In* AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 8 p. refs. (For availability see N74-14271 05-20)

The formation of nitric oxide in premixed propane, ethylene and acetylene flames at 1 atm has been measured. Large overconcentrations of NO were found in very fuel rich flames. The NO formation in flames could be reasonably separated into three classes: (1) Zeldovich mechanism with equilibrium O atom concentration, (2) Zeldovich mechanism with the remaining excess O atom concentration, and (3) other reactions involving radicals as CH, C, C<sub>2</sub>. The distinction of these classes can be made by studying the temperature dependence of the NO formation, by analysing the curvature of the NO profiles, by relating the rate of NO formation to O atom concentrations and by measuring HCN in some flames. The analysis of the temperature dependence of the NO formation in propane flames gave evidence that in these flames with stoichiometric ratios between 1.2 and 1.4 and temperatures between 1850 K and 2400 K, reaction

class (c) is the main reaction channel. A comparison of flames which have the same temperature at the same mixture strength, but differ in the chemical structure of the fuel, shows higher NO concentrations for acetylene flames and somewhat smaller NO concentrations for methane flames relative to the concentrations in propane flames. Author

**N74-14288** Direction Technique Avions, Paris (France). Aerospatiale

**MEASURE OF MINOR CONSTITUENTS IN THE STRATOSPHERE BY CONCORDE 001 (MESURES DES CONSTITUANTS MINEURS DANS LA STRATOSPHERE PAR CONCORDE 001)**

R. Joatton. *In* AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 7 p. refs. *In* FRENCH (For availability see N74-14271 05-20)

The effect of aerospace vehicles on stratospheric pollution as measured by equipment onboard the Concorde 001 are discussed. Data cover carbon monoxide, several nitrogen oxides, and hydrocarbon emissions. Special attention was given to possible reductions of stratospheric ozone and the effect of such reductions on the environment. Transl. by E. H. W.

**N74-14289** National Gas Turbine Establishment, Pyestock (England)

**SOOT FORMATION IN RICH KEROSENE FLAMES AT HIGH PRESSURE**

F. H. Holderness and J. J. Macfarlane. *In* AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 9 p. refs. (For availability see N74-14271 05-20)

Soot appearing in gas turbine exhaust products originates within the primary flame. Model combustor experiments are summarized in which soot formation was measured in a reacting kerosene-air flame of uniform composition. Operating conditions are 6 to 21 bar and equivalence ratio 0.8 to 1.8. Chemical equilibrium was not attained for equivalence ratios much above unity. The available oxygen reacted initially with a portion of the fuel, the remainder appearing as pyrolysis product. The total amount of this material, including soot, was roughly dependent on equivalence ratio, independent of other variables. The fraction fully degraded to soot increased sharply on raising pressure from 6 to 11 bar. There was a well defined threshold of soot formation at equivalence ratio 1.3 to 1.4 in premixed flames. Soot was observed at weaker conditions than this in spray flames and the formation rate rose to approximately 10 percent of the input carbon at equivalence ratio 1.8. Author

**N74-14290** Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering

**SOOT OXIDATION KINETICS AT COMBUSTION TEMPERATURES**

John P. Appleton. *In* AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1973. 11 p. refs. (For availability see N74-14271 05-20)

(Grant NSF GK 33933)

Comparisons between soot oxidation rate measurements obtained in laboratory flames and in a recent shock-tube investigation are made with previously reported measurements of the surface oxidation rate of bulk samples of pyrolytic graphite. On the basis of these comparisons it is concluded that the surface oxidation rate mechanisms for soot and pyrolytic graphite are the same and that the rates are predicted by a semiempirical expression, originally proposed for graphite oxidation, which expresses the specific surface oxidation rate in terms of the surface temperature and the gas phase partial pressure of oxygen. This expression provides a method of estimating soot oxidation rates which is suitable for use in engineering design and performance studies of most practical combustion systems, such as gas turbine combustors. Author

**N74-14291\*** Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering

**PARAMETERS CONTROLLING NITRIC OXIDE EMISSIONS FROM GAS TURBINE COMBUSTORS**

John B. Heywood and Thomas Mikus. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 16 p refs (For availability see N74-14271 05-20)  
(Grant NCR-22-009-378)

Nitric oxide forms in the primary zone of gas turbine combustors where the burnt gas composition is close to stoichiometric and gas temperatures are highest. It was found that combustor air inlet conditions, mean primary zone fuel-air ratio, residence time, and the uniformity of the primary zone are the most important variables affecting nitric oxide emissions. Relatively simple models of the flow in a gas turbine combustor, coupled with a rate equation for nitric oxide formation via the Zeldovich mechanism are shown to correlate the variation in measured NOx emissions. Data from a number of different combustor concepts are analyzed and shown to be in reasonable agreement with predictions. The NOx formation model is used to assess the extent to which an advanced combustor concept, the NASA swirl can, has produced a lean, well-mixed primary zone generally believed to be the best low NOx emissions burner type. Author

N74-14292 California Univ Berkeley Dept of Mechanical Engineering

#### FACTORS CONTROLLING POLLUTANT EMISSIONS FROM GAS TURBINE ENGINES

R. F. Sawyer, N. P. Cernansky, and A. K. Oppenheim. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 12 p refs (For availability see N74-14271 05-20)  
(Grants AF-AFOSR-2299-72, AF-AFOSR-2200-72)

Primary pollutants emitted by aircraft gas turbine engines are carbon monoxide, hydrocarbons, aldehydes, smoke, particulates, and nitric oxide. Factors controlling emissions of these pollutants are analyzed on the basis of aircraft engine exhaust composition and laboratory studies of gas turbine combustion processes. Moreover, an analytical prediction of the effect of aircraft operating parameters on the emission of nitric oxide is also given. The formation and destruction of these pollutants were investigated in a laboratory gas turbine combustor. The oxidation of carbon monoxide, hydrocarbons, and aldehydes was measured in the dilution zone where thermal quench phenomena were observed. The apparent oxidation of particulates in the dilution zone was also observed. The formation of nitric oxide was observed in the primary zone and in the first part of the dilution section of the combustor. Operational conditions and engine parameters were studied analytically, yielding rational criteria for the prediction of their effect on the emission of nitric oxide. Author

#### N74-14293 Norwegian Inst. for Air Research, Kjeller A SYSTEMATIC APPROACH TO THE STUDY OF THE CONNECTION BETWEEN EMISSION AND AMBIENT AIR CONCENTRATIONS

Knut Erik Groensker. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 10 p refs (For availability see N74-14271 05-20)

A systematic approach to study the effect of a complex source distribution on the ambient air quality is described. Measurements of emission, meteorological parameters, and ambient air concentrations are used to develop a quantitative model describing the important physical and chemical processes. The model is mathematically formulated in a modified form of the continuity equation for the pollution component. To improve the model, regression analysis can be used. An example of this approach is given in the study of air pollution in Oslo where it has been shown that a systematic vertical motion is the most important process to clean the air in Oslo during inversion situations. Some comments are made on the model approach to the air pollution problem around an airport. Author

N74-14294 Office National d'Etudes et de Recherches Aeronautiques Paris (France)

#### THEORETICAL STUDY OF THE RESIDUAL EVOLUTION OF POLLUTING PRODUCTS IN TURBOJET EXHAUSTS

Roland Borghi. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 11 p refs. In FRENCH. ENGLISH summary (For availability see N74-14271 05-20)

Efforts underway to predict and control the quantity of CO and NO polluting products produced by turbojet nozzle outlets are reviewed. A numerical method, taking into account turbulent mixing phenomena and nonequilibrium chemical reactions, was developed. Several reaction models were compared and show that CO immediately transforms into CO2 upon exhaust. However, a much longer time is needed for NO to disappear. Author

#### N74-14295 Pratt and Whitney Aircraft, West Palm Beach, Fla. DEVELOPMENT AND VERIFICATION OF AN ANALYTICAL MODEL FOR PREDICTING EMISSIONS FROM GAS TURBINE ENGINE COMBUSTORS DURING LOW-POWER OPERATION

Stanley A. Mosier, Richard Roberts, and Robert E. Henderson (AFAPL). In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 12 p refs (For availability see N74-14271 05-20)

A theoretical combustor model was formulated for predicting concentrations and distributions of unburned hydrocarbons, and carbon monoxide from gas turbine engine combustors. Essential components of this model include an internal flowfield model, a treatment of the physical combustion process, and a treatment of hydrocarbon oxidation kinetics. Model components were incorporated into a computer program with a single model structure for simplicity. An experimental program was also conducted to evaluate combustor design techniques for lowering emission levels and to provide experimental data against which the theoretical model could be tested. Burner exit-plane measurements of unburned hydrocarbons, carbon monoxide, nitrogen oxides, temperature, and pressure were made. Predictions of exhaust species concentrations and distributions were made using the theoretical combustor model in support of the experimental program. Results are discussed with respect to internal aerodynamic and chemical kinetic arguments within the framework of the theoretical formulation. Author

#### N74-14296 Politecnico di Milano (Italy). Ist. di Macchine AN EXPERIMENTAL RESEARCH ON THE BEHAVIOR OF A CONTINUOUS FLOW COMBUSTION CHAMBER

C. Casoli, A. Coghe, U. Ghezzi, and S. Pasini. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 11 p refs (For availability see N74-14271 05-20)

In relation to the combustion phenomena area, a continuous flow test bench was developed to study gas turbine combustion. The feeding system provided a wide range of air-fuel ratio and working pressure for investigating different test conditions. The combustion chamber was arranged to sample the gas composition in different positions, and to measure other magnitudes such as pressure and air and fuel mass flow rate. The species analyzed were carbon monoxide, unburned hydrocarbon, and nitrogen oxides. The primary concern was the evolution of the above species along the can-type liner and the determination of optimum working conditions. The typical design features of the combustion chamber described allow a comparison of the results obtained to real systems, but the kinetic and fluid dynamic phenomena concerned with the combustion process make the extrapolation of the results difficult for conditions very far from the experimental ones in this research. Author

#### N74-14297 Air Force Dept., Washington, D.C. SESSION 4: DESIGN OPENING REMARKS

W. Moe. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 2 p (For availability see N74-14271 05-20)

Comments are made concerning the design of combustors. Emphasis is placed on the necessity of reducing jet engine pollution without detracting from jet performance. Military involvement in aircraft chemical pollution control is also discussed. KMM

N74-14298 Office National d'Etudes et de Recherches Aeronautiques Paris (France)

#### MODELIZATION OF TURBOMACHINE COMBUSTORS FOR POLLUTION STUDIES

Marcel Barrere. In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 21 p refs. In FRENCH. ENGLISH summary (For availability see N74-14271 05-20)

A survey was made of models currently proposed to calculate the evolution of polluting species in a turbomachine combustor. Efforts were made to improve the models in order to: (1) predict the polluting species generation rate by the combustor for various functioning conditions, (2) determine main parameters acting on this polluting rate, and (3) design new optimized combustors generating a minimum of pollutants while retaining the same performance. Author

**N74-14289** California Univ., Berkeley Dept. of Mechanical Engineering  
**SMOKE SUPPRESSANT ADDITIVE EFFECTS ON PARTICULATE EMISSIONS FROM GAS TURBINE COMBUSTORS**

P. J. Pagni, L. Hughes, and T. Novakov. In AGARD Atmospheric Pollution by Aircraft Engines. Sep 1973. 11 p. refs. (For availability see N74-14271 05-20)  
(Grants NSF GK-27895, EPA-AP-385)

The effects of manganese based additives on the mass, size distribution, and chemical composition of particulate emissions from gas turbine combustors are described. Experiments show that the additive, 2-methyl cyclopentadienyl manganese tricarbonyl, can increase mass emissions if used excessively. The additive shifts the emitted particle size distribution toward many more much smaller particles, thereby reducing visibility primarily by reducing the size of the emitted particles. X-ray photoelectron spectroscopy studies have determined that the chemical state of the emitted manganese is manganese monoxide. It is recommended that combustor redesign and collection techniques be employed whenever possible to suppress particulate emissions from aircraft and test facilities. Author

**N74-14300** General Electric Co., Cincinnati, Ohio Advanced Combustion and Emissions Control Technology  
**TECHNOLOGY FOR THE REDUCTION OF AIRCRAFT TURBINE ENGINE EXHAUST EMISSIONS**  
Donald W. Bahr. In AGARD Atmospheric Pollution by Aircraft Engines. Sep 1973. 13 p. refs. (For availability see N74-14271 05-20)

Tests of both production and advanced engines were conducted to determine the emission characteristics of aircraft turbine engines. The results of these engine evaluations are presented. Also presented are the results of exploratory investigations to define and develop design approaches for reducing the carbon monoxide, unburned hydrocarbons, and nitrogen oxides emission levels of high performance, annular combustors. With already developed low smoke emission characteristics in these latter investigations, the emissions level reductions obtainable through the use of advanced primary combustion zone stoichiometry control methods and advanced fuel injection techniques were evaluated. In addition results are presented on the use of water injection techniques to suppress the formation of nitrogen oxides in combustors. It is concluded that future engines can be developed with significantly lower levels of these gaseous emissions than those of current engines. Author

**N74-14301** Cranfield Inst. of Technology (England) School of Mechanical Engineering  
**A PRELIMINARY STUDY ON THE INFLUENCE OF FUEL STAGING ON NITRIC OXIDE EMISSIONS FROM GAS TURBINE COMBUSTORS**  
A. H. Lefebvre and R. S. Fletcher. In AGARD Atmospheric Pollution by Aircraft Engines. Sep 1973. 7 p. refs. (For availability see N74-14271 05-20)

The results are presented from a preliminary investigation carried out on a tubular aircraft combustor chamber which was perfectly standard apart from an additional fuel injector located just downstream of the primary zone. Measurements of nitric oxide exhaust emissions were carried out over a range of fuel to both primary and secondary zones and the results compared with predictions based on a previously derived mathematical model. Author

**N74-14302\*** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio  
**DESIGN AND EVALUATION OF COMBUSTORS FOR REDUCING AIRCRAFT ENGINE POLLUTION**  
Robert E. Jones and Jack Grobman. In AGARD Atmospheric Pollution by Aircraft Engines. Sep 1973. 8 p. refs. (For availability see N74-14271 05-20)

Various techniques and test results are briefly described and referenced for detail. The effort arises from the increasing concern for the measurement and control of emissions from gas turbine engines. The greater part of this research is focused on reducing the oxides of nitrogen formed during takeoff and cruise in both advanced CTOL, high pressure ratio engines, and advanced supersonic aircraft engines. The experimental approaches taken to reduce oxides of nitrogen emissions include the use of multizone combustors incorporating reduced dwell time, fuel-air premixing, air atomization, fuel preevaporation, water injection, and gaseous fuels. In the experiments conducted to date, some of these techniques were more successful than others in reducing oxides of nitrogen emissions. Tests are being conducted on full-annular combustors at pressures up to 6 atmospheres and on combustor segments at pressures up to 30 atmospheres. Author

**N74-14303** Societe Europeenne d'Etudes et d'Essais d'Environnement, Buc (France)  
**MOTORIST POINT OF VIEW ON THE EFFECTS OF LOW BURNING RATES ON POLLUTION (POINT DE VUE DU MOTORISTE SUR LA CONCEPTION DES FOYERS A FAIBLE TAUX DE POLLUTION)**

Alain Quillevers, Raymond Brancan, and Jean Decouflet. In AGARD Atmospheric Pollution by Aircraft Engines. Sep 1973. 19 p. refs. In FRENCH. (For availability see N74-14271 05-20)

Possible ways of reducing CO, NO, and hydrocarbons emitted by turbojets are discussed by their designers. It was suggested that high performance annular combustion chambers, reduced air speeds, and modification of existing designs may reduce emissions, particularly NO emissions. The use of injector systems to reduce pollution was also examined. Transl. by E. H. W.

**N74-14304** Air Force Aero Propulsion Lab., Wright Patterson AFB, Ohio  
**AIRCRAFT GAS TURBINE POLLUTANT LIMITATIONS ORIENTED TOWARD MINIMUM EFFECT ON ENGINE PERFORMANCE**

Robert E. Henderson and William S. Blazowski. In AGARD Atmospheric Pollution by Aircraft Engines. Sep 1973. 13 p. refs. (For availability see N74-14271 05-20)

The proposed Environmental Protection Agency (EPA) regulations for aircraft engine emissions are examined in terms of their impact on the application to military aircraft gas turbine engines. A quantitative assessment of current engine emission levels, design trends, and potential emission control techniques is presented. It is concluded that special considerations must be afforded to military aircraft relative to direct application of EPA regulations; however, many future emission-reducing advances will be applicable to military gas turbines. U. S. Air Force goals were established to insure that new engines take advantage of this technology and are in accordance to the greatest degree possible with what EPA requires of commercial aircraft. These goals are in terms of minimum idle combustion inefficiency, maximum allowable oxides of nitrogen (lb 1000 lb fuel), and maximum allowable smoke number. The rationale behind using these parameters and the means by which the numerical limitations were derived are described. Author

**N74-14305** Pisa Univ. (Italy) Ist. di Macchine  
**PHOTOMETRIC MEASUREMENTS OF EXHAUST SMOKE TRAILS BY JET ENGINES**  
M. Lucchesini and D. Dini. In AGARD Atmospheric Pollution by Aircraft Engines. Sep 1973. 12 p. refs. (For availability see N74-14271 05-20)

The purpose of this study is twofold: (1) developing a photographic photometry method to measure density and visibility of exhaust smoke trails, and (2) obtaining an objective index for the smoke emission on degree by turbojets. Tests show the

PW JT8D9 as being one of the most contaminating jet engines in airline service, giving T values of about 74 percent. Transmission T values were measured in many cases at different distances from the nozzle and for several angles between optical and trail axes. This is done to show dependence of T from the aerodynamic airplane/engine configuration and from the optical path L through the trail.

Author

**N74-14306** Aerospace Medical Research Labs. Wright-Patterson AFB, Ohio. Toxicology Branch.

**ENVIRONMENTAL TOXICOLOGICAL IMPACT OF AIRCRAFT OPERATIONS**

Kenneth C. Back. In AGARD Atmospheric Pollution by Aircraft Engines. Sep. 1972. 6 p. refs. (For availability see N74-14271 05-20)

Sources of pollution from aircraft operation include such chemical substances and decomposition products as aviation gasolines, jet fuels, advanced fuels, oils, lubricants, hydraulic fluids, coolants, deicers, and various additives used in these formulations. These may enter the environment as the result of normal mission accomplishment and attendant ground operations, inadvertent malfunctions and spillage, and necessary periodic disposal processes. Physiological effects of the more important compounds which are current problems with aircraft pollutants, problems associated with obtaining such biological data, mechanisms necessary to comply with current pollution control directives, and standards which are now functional are also discussed.

Author

**N74-15349\*** Advisory Group for Aerospace Research and Development. Paris (France).

**TECHNICAL EVALUATION REPORT ON AGARD TECHNICAL MEETING ON ATMOSPHERIC POLLUTION BY AIRCRAFT ENGINES**

Paul A. Libby (Calif. Univ., La Jolla). Nov. 1973. 6 p. Presented at the Proc. of the Propulsion and Energetics Panel 41st Meeting, Regent's Park, Engl. 9-13 Apr. 1973.

(AGARD AR 63. AGARD CP 125. Avail. NTIS HC \$3.00)

The environmental problems associated with aircraft operations are discussed. Emphasis is placed on the general problem of air pollution in the neighborhood of airports due to aircraft engine exhaust products. The anticipated benefits from basic combustion research for reducing the pollutants in aircraft engine exhaust are examined. The necessity to determine the amount of pollution caused by aircraft engines as compared with vehicular traffic and adverse meteorological conditions as a basis for most effective propulsion system modifications is stressed.

Author



## 21 NAVIGATION

Includes guidance, autopilots, star and planet tracking, inertial platforms, and air traffic control. For related information see also 07 Communications

**N72-22621#** Advisory Group for Aerospace Research and Development, Paris (France)

### GUIDANCE AND CONTROL DISPLAYS

Feb 1972 237 p refs. Presented at 13th Meeting of Guidance and Control Panel of AGARD, Paris, 19-21 Oct 1971

(AGARD-CP-98) Avail: NTIS

Conference papers are presented on guidance and control display design for aerospace vehicles. The particular areas of investigation are visual criteria, workload criteria, validation of design criteria, VTOL aircraft displays, displays for specific applications, new technology, and testing and evaluation of displays. For individual titles, see N72-22622 through N72-22644

**N72-22622#** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Flight Deck Development Branch

### THE STATUS OF HUMAN PERCEPTUAL CHARACTERISTIC DATA FOR ELECTRONIC FLIGHT DISPLAY DESIGN

Keith J. Burnett. In AGARD Guidance and Control Displays Feb 1972 10 p refs (See N72-22621 13-21)

Avail: NTIS

The human factors literature was searched and analyzed for human perceptual characteristic data relating to the design of individual electronic flight displays. Some of the more interesting data obtained are summarized and include flicker, visual acuity, display resolution, luminance, alphanumeric legibility, scale legibility, information coding, display size, and the effect of environmental variables on these quantities. Wherever possible the data are analyzed and presented so as to point out significant variables and data trends not specifically discussed in the original works. Author

**N72-22623#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst fuer Flugfuehrung

### A LIMITED STUDY OF THE TRADE OFF BETWEEN LUMINANCE AND COLOR CODING IN ELECTRONIC AIRCRAFT DISPLAYS

Ralf Beyer. In AGARD Guidance and Control Displays Feb 1972 9 p refs (See N72-22621 13-21)

Avail: NTIS

The effectiveness of luminance and color coding are compared as means for coding display elements in electronic displays. First a review of some past investigations is given. Next some experiments are described which contain an immediate-response task, a single-axis tracking experiment with discontinuous secondary task, tachistoscopic experiments, and the exploration of subjective judgements on different types of color coding in an experimental electronic display. In these experiments the only variable is the type of coding (luminance or color) used for the display elements and the various responses obtained are discussed. Author

**N72-22624#** Human Engineering Labs., Aberdeen Proving Ground, Md

### WHAT COLOR DISPLAY ELEMENT

John A. Barnes. In AGARD Guidance and Control Displays Feb 1972 11 p refs (See N72-22621 13-21)

Avail: NTIS

The results are presented of research directed toward determining the best possible colors to use for the elements of a multicolored aircraft display to insure a minimum number of instrument reading errors. A survey of the American manufacturers of multicolored mechanical aircraft displays provided a list of nine colors generally used as background colors and a like number of generally used pointer colors. An integrally illuminated

test instrument was built which had the capability of presenting to a test subject any of these background and pointer colors in combination. The lighting of the test instrument was controlled at either of two illumination levels for each background color and was available, with this control, as a red lighting system or as a blue-white lighting system. These results provide the instrument manufacturers with twenty pointer and background combinations which can be expected to produce less than a one percent instrument scale reading error, regardless of the lighting system used and at illumination levels as low as .01 foot Lamberts.

Author

**N72-22625#** Litton Systems, Inc., Van Nuys, Calif. Data Systems Div

### THE INTEGRATED COCKPIT PROCEDURE FOR IDENTIFYING CONTROL AND DISPLAY REQUIREMENTS OF AIRCRAFT IN ADVANCED TIME PERIODS

John V. Murphy and Bernard S. Gurman (ECOM, Fort Monmouth, N. J.). In AGARD Guidance and Control Displays Feb 1972 7 p refs (See N72-22621 13-21)

Avail: NTIS

An adaptation of the integrated cockpit research procedure was used to define control and display requirements for the next generation utility transport helicopter under consideration by the U.S. Army. A control and display requirements analysis was conducted based upon the derivation of specific functions necessary for accomplishing four specified missions. Control/display mechanization was derived from specific mission functions. A time-based load analysis was performed utilizing computer processing techniques to make task adjustments in real time and provide a printout of how the tasks in each mission segment could be adjusted to meet the mission requirement. The technique also provided an analysis of contingency situations and denoted overload conditions that occurred. The hard copy mock-up was a full-scale cockpit shell in which the alternative mission control/display configurations could be illustrated. The mock-up contained realistic flight controls and audiovisual projector units that simulated vertical and horizontal situation display formats. Author

**N72-22626#** Honeywell, Minneapolis, Minn. Systems and Research Div

### DESIGN IMPLICATIONS OF A BETTER VIEW OF THE MULTICHANNEL CAPACITY OF A PILOT

O. H. Lindquist. In AGARD Guidance and Control Displays Feb 1972 6 p refs (See N72-22621 13-21)

Avail: NTIS

A major result of a recently completed study is the prediction and measurement of multichannel pilot performance, which significantly increases his information handling capability beyond that predicted by today's techniques. Current techniques of predicting man-machine interactions were shown to be in error by an order of magnitude in some measurements related to human channel capacity. The results of this experimental work are presented and system design implications for pilot capability and limitations are discussed. Author

**N72-22627#** Systems Technology Inc., Hawthorne, Calif

### SYSTEMATIC MANUAL CONTROL DISPLAY DESIGN

W. F. Clement, D. T. McRuer, and R. H. Klein. In AGARD Guidance and Control Displays Feb 1972 10 p refs. Sponsored in part by NASA and JANAIR (See N72-22621 13-21)

(NASA-CR 126256) Avail: NTIS CSCL 01D

The principles are outlined of guidance and control display design based on interactions with human psychomotor activity. The inspirations for eye movement studies in flight control and monitoring tasks, and the relationship of eye scanning phenomena to pilot describing functions and remnant are summarized. Several measures of pilot workload in control tasks are discussed.

Excess control capacity, in particular has great promise in quantifying a practical definition of workload. It is a major workload connector with pilot opinion rating and whole-task effective time delay. Further connections with load equalization, scanning workload, physiological measures of neuromuscular tension, and the effects of additional modalities on visual workload are illustrated. Author

**N72-22628#** Forschungsinstitut fuer Anthropotechnik, Meckenheim (West Germany).

**A SYMBOL GENERATOR FOR THE ANTHROPOTECHNICAL EVALUATION OF INTEGRATED DISPLAYS**

K.-F. Kraus. In AGARD Guidance and Control Displays Feb. 1972. 7 p. refs. (See N72-22621 13-21)  
Avail NTIS

A freely programmable low-cost high-quality character-generator is described, which uses a hybrid principle of generation. The writing is performed by a combined stroke writing and Lissajous procedure that results in an increased display quality. The binary information needed is stored in a core memory. The applied circuit design enables the writing of a continuous curve, which may be arbitrarily composed of dots and lines. The presentation of alphanumeric symbols and complex geometric figures is performed using a 15 by 15 dot matrix for construction. Color coding capability is provided by multilayer CRT. Since programming of the displayed picture is done by simple statements on punched tape, the generator becomes an excellent and flexible experimental device for the human engineering evaluation of electronic displays. An example for application is cited. Author

**N72-22629#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

**A METHOD OF MAN-DISPLAY/CONTROL SYSTEM EVALUATION**

Ruediger Seifert (British Aircraft Corp., Preston, England), Alan F. Daniels (British Aircraft Corp., Preston, England), and Klaus Schmidt. In AGARD Guidance and Control Displays Feb. 1972. 9 p. refs. (See N72-22621 13-21)  
Avail NTIS

A method of evaluating the design and assessing the layout of an aircraft cockpit is described. Factors significantly affecting the design, such as scenario, operational, and equipment requirements are introduced and a description of the rig facility provided. The use of the Cooper-Harper rating system, semantic differentials, and guided interviews in the analysis of subject performance and opinion is described. It is concluded that complex man-display/control systems can only be optimized by the adoption of a comprehensive approach to experimental studies. Author

**N72-22630#** Massachusetts Inst. of Tech., Cambridge Mass.-Vehicle Lab.

**INTEGRATED DISPLAY PRINCIPLES AND SOME APPLICATIONS TO V/STOL AIRCRAFT**

Laurence R. Young. In AGARD Guidance and Control Displays Feb. 1972. 7 p. refs. (See N72-22621 13-21)  
(Grant No. 22-009-025)  
(NASA-CH-128153) Avail NTIS CSCL 01D

Design guidelines for pictorial integrated displays are presented, and include the display format and scaling based on expected flight path control requirements. The guidelines are illustrated by the bottom window predictor VTOL display, a perspective glide-slope contact analog V/STOL display, and an airborne air traffic situation display. Author

**N72-22631#** Vereinigte Flugtechnische Werke-Fokke, G.m.b.H. Bremen (West Germany).

**EVALUATION OF AN INTEGRATED FLIGHT DISPLAY FOR THE MANUAL IFF-LANDING OF VTOL AIRCRAFT**

H. J. Kornstaedt and J. Pleiningsdorf. In AGARD Guidance and Control Displays Feb. 1972. 6 p. refs. (See N72-22621 13-21)

Avail NTIS

An integrated flight display for the hovering phase of a VTOL landing was developed. The presentation of information to the pilot is evaluated in simulation by three criteria: landing performance, pilot rating, and measurement of the pilot's mental workload. Adaptation of the display dynamics and the desired landing profile lead to higher level of performance at a decreased workload. Author

**N72-22632#** Ministry of Defence, London (England).

**V/STOL DISPLAYS FOR APPROACH AND LANDING**  
David J. Walters and Ralf Beyer (DFVLR). In AGARD Guidance and Control Displays Feb. 1972. 10 p. (See N72-22621 13-21)

Avail NTIS

The information requirements of a pilot carrying out a V/STOL approach and landing under adverse weather conditions are described, and solutions that were tried out experimentally are analyzed. Among the tentative conclusions are the following: (1) The amount of information needed for V/STOL displays and the independent motion in various axes pose problems in combining and integrating the information channels. It seems possible to combine both a horizontal and a vertical display in one format, the most difficult element to incorporate is the height information. (2) Most current displays were empirically designed without much regard for underlying principles. (3) An optimum cost-effective mix of displays and controls appears to involve automatics for inner loop stabilization and displays with manual control for monitoring outer loop control. (4) Techniques of engineering displays for conventional flight appear adequate for V/STOL. Author

**N72-22633#** Ferranti Ltd., Edinburgh (Scotland).

**A NAVIGATION COMPUTER AND DISPLAY UNIT FOR HARRIER**

Thomas S. Briggs. In AGARD Guidance and Control Displays Feb. 1972. 14 p. refs. (See N72-22621 13-21)  
Avail NTIS

The navigation display and computer for the Harrier strike aircraft is a compact, comprehensive, and self-contained navigation instrument. It contains a pictorial presentation of the navigational situation in the form of a projected moving map, together with the means of storing and selecting the coordinates of a number of destinations or fix points. A variety of numerical information such as latitude and longitude, time-to-go, and ground speed, can be selected and displayed optically superimposed on the projected moving map. The display and computer contains all the facilities required for the management of the navigation aspects of the mission profile in one centralized area of the cockpit instrument panel. Particular attention is given to overcoming the viewing problems associated with the use of projected moving map displays in conditions of high ambient lighting, and to providing navigational control and operational facilities which are easy to use in practice. Author

**N72-22634#** Anacapa Sciences, Inc., Santa Barbara, Calif.

**CONTEMPORARY MAP DISPLAYS**  
James J. McGrath. In AGARD Guidance and Control Displays Feb. 1972. 16 p. refs. (See N72-22621 13-21)

Avail NTIS

A general review of developments and capabilities in airborne map display systems is presented. A brief overview of the complicated history of research, development, and operational use is presented first, and then the development of each of four basic types of map displays is traced from its origin to its present status. The four types are direct-view map displays, projected map displays, combined map/CRT displays, and electronically generated map displays. The main advantages and limitations of each type are noted, and the various ways in which the basic design concepts have been implemented are described. A number of design issues and operational problems of current importance are identified and briefly discussed. Author

**N72-22636#** Smiths Industries Ltd., Bishops Cleeve (England)  
Aviation Div

**THE IMPACT OF ADVANCING TECHNOLOGY ON THE EVOLUTION OF ELECTRONIC HEAD-UP DISPLAY SYSTEMS**

John H. Smith. In AGARD Guidance and Control Displays Feb 1972 10 p (See N72-22621 13-21)

Avail NTIS

The history of electronic head-up display system as applied to military aircraft is outlined. The various major developments demanded by successive avionic system requirements, and the way in which advancing technology, mainly in the area of components, allows these increasingly stringent requirements to be implemented are discussed. The main emphasis is on the engineering and hardware aspects, and systems fitted to current production aircraft such as the Harrier are discussed. Reference is also made to the most recent developments where computation for weapon delivery, or other purposes, can be provided as an integral facility within the electronics unit. Author

**N72-22636#** Elliott Flight Automation, Ltd., Rochester (England)  
Airport Works

**SOME ENGINEERING AND OPERATIONAL FACTORS OF MULTISENSOR DISPLAYS**

P. A. Hearne and D. W. Hussey. In AGARD Guidance and Control Displays Feb 1972 14 p (See N72-22621 13-21)

Avail NTIS

The operational advantages of presenting a range of complementary data to the aircrew from which they can make improved deductive judgements is briefly discussed and some operational requirements are outlined. The engineering solutions are shown to favor a raster based display which can accommodate both computed and sensor data in the same format. Methods of display computation and scan conversion associated with this raster technique are described and typical displays produced by these methods are illustrated. Author

**N72-22637#** Compagnie Generale de Telegraphie sans Fil, Paris (France) Div des Equipements Avioniques et Spatiaux  
**INTEGRAL COMMAND AND CONTROL SYSTEM FOR AIRCRAFT [SYSTEME INTEGRE DE CONTROLE ET DE COMMANDE DES AVIONS]**

Marie-Jacques Jullien. In AGARD Guidance and Control Displays Feb 1972 12 p. In FRENCH (See N72-22621 13-21)

Avail NTIS

Operating characteristics and techniques are presented for an aircraft integrated command and control system. The system is designed to ease the primary tasks of pilots in the coming years, tasks which have become increasingly difficult due to machine complexity and steadily growing air traffic density.

Transl. by K. P. D.

**N72-22638#** Air Force Materials Lab., Wright-Patterson AFB, Ohio

**MATERIALS AND TECHNOLOGY FOR NEW INFORMATION DISPLAYS**

Patrick M. Heminger. In AGARD Guidance and Control Displays Feb 1972 9 p refs (See N72-22621 13-21)

Avail NTIS

The current status of electroluminescent materials and devices is reviewed. The limitations of the presently important materials GaP (gallium phosphide) and GaAsP (gallium arsenide phosphide) are discussed, followed by a survey of candidate materials for future display systems. In particular, the potential of groups 2-6 semiconductors is presented along with some recent experimental results. Author

**N72-22639#** Ferrand Optical Co., Inc., Valhalla, N.Y.  
**A MULTIPURPOSE WIDE FIELD, THREE DIMENSIONAL HEAD UP DISPLAY FOR AIRCRAFT**

Joseph A. LaRusse. In AGARD Guidance and Control Displays Feb 1972 10 p ref (See N72-22621 13-21)

Avail NTIS

A system useful to pilots for approach and landing and for navigation is described. Attitude, airspeed, altitude, and spatial location as derived both from analog display which is projected through the windscreen and superimposed on the real world view. The display is a three-dimensional roadway in the sky, down which the aircraft can be flown either for navigation or to a touchdown on the runway. The roadway may also be used to define a holding pattern or even a complete route from takeoff to touchdown. The three-dimensional analog display reduces pilot interpretation time and thereby provides for better aircraft control. Author

**N72-22640#** Motorola, Inc., Scottsdale, Ariz

**A TRUE 3D OR FLAT 2D DISPLAY**

Jordan D. Lewis (Battelle Develop. Corp.) and George P. Walling. In AGARD Guidance and Control Displays Feb 1972 6 p refs (See N72-22621 13-21)

Avail NTIS

A display principle is described for a true 3-D display or a multicolor, solid state, flat panel display. The display volume or surface is a transparent material in which an isolated moving spot is created. Arbitrary 2-D or 3-D figures are generated by rapidly moving the spot in two or three dimensions refreshed at a sufficient rate to eliminate flicker. Data may be entered from conventional sources into the refresh memory, and manual interaction via a movable cursor is possible. The advantages of presenting 3-D information in a true 3-D format are discussed, and applications to display clutter reduction are described. The requirement for a compact, flat panel cockpit display is directly addressed. Author

**N72-22641#** Singer-Kearfott, Little Falls, N.J.

**SPACE TECHNOLOGY APPLICATIONS TO GUIDANCE AND CONTROL DISPLAYS**

Joseph Koprowski. In AGARD Guidance and Control Displays Feb 1972 11 p refs (See N72-22621 13-21)

Avail NTIS

Spacecraft displays with their need for small size, low weight, low power consumption, and high reliability have required all solid state digital displays using electroluminescent or light-emitting diode illumination techniques. Advanced integrated circuit electronics, novel mechanical packaging techniques, and high-reliability assurance programs are used in these displays. These technologies, and several existing and other under-development aerospace displays and control units utilizing these technologies are reviewed. Author

**N72-22642#** Anacapa Sciences, Inc., Santa Barbara, Calif.  
**UTILITY OF THE VERTICAL CONTACT ANALOG DISPLAY FOR CARRIER LANDINGS: A DIAGNOSTIC EVALUATION**

Kenneth D. Cross and Frank R. Cavallero (Naval Missile Center). In AGARD Guidance and Control Displays Feb 1972 11 p refs (See N72-22621 13-21)

(ONR Proj. 0-0077, ONR Proj. 0-0078, ONR Proj. 0-0079)

Avail NTIS

The accuracy of the pictorial vertical situation display generated by a digital computer was evaluated. Position and attitude errors were measured under each of five experimental conditions: a full-scale simulated carrier landing task and four part-tasks. The part-tasks were designed to assess the degree to which display resolution, temporal loading, and control complexity contribute to total system error. All three attitude parameters were controlled with a high degree of accuracy under all conditions. Control of vertical and lateral position in the full-scale simulation condition was accomplished with about the same accuracy and precision as that reported for actual (day) carrier landings in F-4 aircraft. The part-task data revealed that the largest contributor to lateral error was control complexity, whereas display resolution and temporal loading were found to be large and roughly equivalent contributors to vertical error. Author

**N72-27643#** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Flight Deck Development Branch  
**RATE OF CLOSURE AS A PERFORMANCE AS A PERFORMANCE MONITORING PARAMETER**

Eldon M. Bobbert and Kenneth R. Woodruff (Sys. Res. Lab., Inc., Dayton, Ohio) *In* AGARD Guidance and Control Displays Feb. 1972 11 p. refs (See N72-22621 13-21)

Avail. NTIS

Surveys on approach and landing accidents revealed the need for rate-of-closure information. Presenting the information and subjecting it to operational criticism were accomplished with a simulation evaluation of a modified Attitude Director Indicator (ADI) incorporating the rate-of-closure information, a two phase flight test evaluation of the same indicator, and a simulation evaluation of a cathode ray tube ADI with rate-of-closure information presented similarly to how it is presented in the electromechanical ADI. The results are explicit in that rate-of-closure information is a requirement in the approach and landing modes and does a good job as a performance monitoring parameter. Author

**N72-22644#** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Flight Deck Development Branch  
**THE ELECTROLUMINESCENT LIGHTING RESEARCH PROGRAM**

David L. Turney and Leroy Addis (Lear Siegler, Inc., Grand Rapids, Mich.) *In* AGARD Guidance and Control Displays Feb. 1972 11 p. refs (See N72-22621 13-21)

Avail. NTIS

Experiments flown in a T-39 aircraft by experienced pilots were designed to simulate different types of operational flights by progressively increasing the external visual task loading on the pilot. Both objective measurements and pilot opinion data were obtained on display illumination under external ambient illumination ranging from twilight to night no-moon conditions. Photometric data showed that the pilot's display lighting requirements were influenced by the outside illumination only when this illumination exceeded 001 foot candles. When the night illumination fell below this level, display illumination was primarily influenced by the pilot's preflight dark adaptation; the type of information required for successful mission completion, the priority the pilot placed on the information available, and the effects of cockpit lighting on display legibility. Author

**N72-27681#** Advisory Group for Aerospace Research and Development, Paris (France)

**GUIDANCE AND CONTROL OF TACTICAL MISSILES**

May 1972 116 p. refs

(AGARD-LS-52) Avail. NTIS HC \$8.00

The control and guidance of tactical missiles with emphasis on cost, reliability, and performance are discussed. The utility of modern analysis and evaluation tools and techniques associated with the several commonly used control and guidance concepts are also examined. For individual titles, see N72-27682 through N72-27693.

**N72-27682** Martin Marietta Corp., Orlando, Fla.  
**GENERAL CONSIDERATIONS IN GUIDANCE AND CONTROL TECHNOLOGY**

Philip C. Gregory *In* AGARD Guidance and Control of Tactical Missiles May 1972 14 p. (For availability see N72-27681 18-21)

A particular set of mission requirements for an air to air missile and an automated design process to synthesize these requirements into the preliminary design of a missile and guidance system are described. This process makes use of the CAMS (Computer Aided Missile Synthesis) digital computer program which was developed to: (1) synthesize missile configurations including the guidance, controls, secondary power, warhead and propulsion subsystems; (2) furnish resulting flight performance including trajectories and miss distance; and (3) estimate unit costs. Author

**N72-27683** Boeing Co., Seattle, Wash. Aerospace Group  
**DEVELOPMENT OF CONTROL SYSTEM REQUIREMENTS**  
 Robert Goodstein *In* AGARD Guidance and Control of Tactical Missiles May 1972 7 p. (For availability see N72-27681 18-21)

The development of control system requirements for tactical missiles is discussed. The timing of control system requirements and the manner in which requirements are incorporated are described. Three examples are presented to show the variety of issues, candidate solutions, and selections of control systems to meet requirements. The type of weapon system requirement, process of analysis, and reasoning on concept selection are included to show application to advanced missile design. Author

**N72-27684** McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

**ADJOINT SOLUTIONS TO INTERCEPT GUIDANCE**

D. L. Pitman *In* AGARD Guidance and Control of Tactical Missiles May 1972 5 p. (For availability see N72-27681 18-21)

The adjoint equations yielding the error sensitivities of a linear system are explained. The Laplace transforms representing the solutions of the adjoint equations of a linear interceptor guidance system are developed. The solutions for an interceptor, represented by a first order lag and utilizing proportional navigation, are derived. Author

**N72-27685** McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

**OPTIMIZATION**

D. L. Pitman *In* AGARD Guidance and Control of Tactical Missiles May 1972 4 p. (For availability see N72-27681 18-21)

The procedure for optimizing a linear system against a quadratic cost function is developed by the method of completing a square. The optimal intercept guidance law against a nonmaneuvering target when the cost is energy lost to drag is shown to be proportional navigation with a gain of 3. Author

**N72-27686** McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

**KALMAN FILTER**

D. L. Pitman *In* AGARD Guidance and Control of Tactical Missiles May 1972 6 p. (For availability see N72-27681 18-21)

The Kalman filter is developed as a rational application of Gauss method or least mean square error summing, which adds together independent measurements and estimates proportionally to the inverse of the variances of expected errors. The discrete measurement summer is developed into the continuous filter by shortening the time between measurements. Author

**N72-27687** Royal Aircraft Establishment, Farnborough (England)  
**NUMERICAL ANALYSIS AND SIMULATION EVOLUTION**  
 E. Heap *In* AGARD Guidance and Control of Tactical Missiles May 1972 7 p. (For availability see N72-27681 18-21)

A review is given of the quantitative advantages and disadvantages of digital and analogue computer techniques for the simulation of missile guidance and control, and a methodology of using hybrid simulation is developed. It is shown how a hybrid computer can be used to aid the choice of an acceptable missile system within a wide spectrum of complexity particularly when many non-linear factors and statistical aspects are involved. Using this facility mathematical modelling not only helps specific projects in their R & D phases, but it can contribute to management decisions in feasibility studies in the choice of missile instrument combinations and in the specification of their desired standard of performance. It can also safeguard against complex systems being over designed to the detriment of their cost. Author

**N72-27688** Martin Marietta Corp., Orlando, Fla.  
**LABORATORY TECHNIQUES AND EVALUATION METHODOLOGY**

Philip C. Gregory. In AGARD Guidance and Control of Tactical Missiles. May 1972. 10 p. (For availability see N72-27681 18-21)

The characteristics of typical electro-optical terminal guidance subsystems including area correlator and gated trackers are furnished to define those parameters (aim and lock on capability, tracking accuracy, tracking bandwidth, aspect angle capability, sensitivity to target and light level variations, acquisition envelope, and range closure effects) which are important to the system user. A laboratory designed to repeatedly measure these properties is described. Typical area correlator tracker characteristics are furnished and a run schedule defined to evaluate the performance parameters described. An economic analysis is presented to illustrate the potential cost savings over flight test. Author

**N72-27689** Boeing Co., Seattle Wash. Aerospace Group  
**GUIDANCE LAW APPLICABILITY FOR MISSILE CLOSING**  
 Robert Goodstein. In AGARD Guidance and Control of Tactical Missiles. May 1972. 6 p. (For availability see N72-27681 18-21)

Guidance law general types to produce missile steering signals from sensed target information leading to suitably close miss distances are discussed. Miss distance variations for the different guidance laws are displayed for an air target intercept as target and missile characteristics are changed. A general comparison of guidance law applicability is presented for air and surface targets. Author

**N72-27690** Aeronautical Systems Div., Wright-Patterson AFB Ohio

**SELF-CONTAINED GUIDANCE TECHNOLOGY**

R. W. Acus, Jr. In AGARD Guidance and Control of Tactical Missiles. May 1972. 18 p. refs. (For availability see N72-27681 18-21)

Inertial technology for a self-contained guidance capability applicable to tactical air-to-ground missiles is discussed. The basic inertial system, which consists of accelerometers, gyros and a computer, is immune to outside interference, and therefore ideally suited to military applications in a hostile environment. Inertial technology has progressed to a point where equipment size and cost are within reason for use with the tactical missile. The basic principles and limitations of inertial guidance, including theory of operation, and physical and analytic coordinate system stabilization are presented. Sources of error and the propagation of these errors are described. Various methods of alignment, and system mechanization are considered. The state of the art, and the research and development process for inertial systems is discussed. Factors influencing the research and development process are identified along with the relationship between inertial system reliability and cost. Author

**N72-27691** Aeronautical Systems Div., Wright-Patterson AFB Ohio

**APPLICATION OF INERTIAL TECHNOLOGY TO A G MISSILES**

R. W. Acus, Jr. In AGARD Guidance and Control of Tactical Missiles. May 1972. 11 p. refs. (For availability see N72-27681 18-21)

Inertial technology for airborne, stand off tactical weapon systems both as a midcourse guidance system and when used in conjunction with a terminal guidance sensor is discussed. The capabilities of pure inertial guidance are examined as the midcourse guidance system for a stand off missile. The relationships between enemy defenses, aircraft capability and missile performance are used to define a hypothetical mission and a set of guidance system requirements. Error magnitudes are selected and missile positional error is determined as a function of range. The stand off range of this particular weapon system is limited by the performance of the midcourse guidance system. Various methods of improving midcourse guidance performance are explored. The advantages and limitations of an aided inertial system are reviewed with emphasis on retaining the advantages of the self-contained system. Author

**N72-27692** Royal Aircraft Establishment, Farnborough (England)  
**METHODOLOGY OF RESEARCH INTO COMMAND-LINE-OF-SIGHT AND HOMING GUIDANCE**

E. Heap. In AGARD Guidance and Control of Tactical Missiles. May 1972. 9 p. (For availability see N72-27681 18-21)

Research of command-to-line-of-sight (CLOS) guidance and semi-active homing missile systems is presented. It discusses the kinematics of various guidance laws from CLOS to pursuit courses and proportional navigation from a fundamental point of view. The interaction between the guidance requirements and the missile system is covered and it is shown that the autopilot and sensor effects need to be considered in hybrid computer simulations. The implications on computer requirements for optimum filtering are also discussed. Author

**N72-27693** Raytheon Co., Bedford Mass. Missile Systems Div.

**PULSE DOPPLER MISSILE GUIDANCE: REPRESENTATIVE PARAMETERS AND ASSOCIATED FIRE CONTROL CONSIDERATIONS**

Henry Zuerndorfer, Howard Lynn, and Gordon Kettering. In AGARD Guidance and Control of Tactical Missiles. May 1972. 17 p. ref. (For availability see N72-27681 18-21)

The principal problems and solution options available for all-weather attack of small tactical targets are discussed. The requirement for all-weather operation against relatively small and possibly mobile targets dictates the use of microwave guidance sensors. The problems of detection and the tracking and fire control considerations associated with the attack of three generic types of tactical targets are presented. The characteristics of the available sensors are described and the applications for various situations are examined. Author

**N73-20684#** Advisory Group for Aerospace Research and Development, Paris (France)

**INERTIAL NAVIGATION COMPONENTS AND SYSTEM**

Feb. 1973. 402 p. refs. In ENGLISH, partly in FRENCH. Presented at the 15th Meeting of the Guidance and Control Panel of AGARD, Florence 2-5 Oct. 1972.

(AGARD-CP 116). Avail. NTIS HC \$22.25.

The proceedings of a conference on inertial navigation components and systems are presented. The objective of the meeting was to provide current information of inertial navigation developments and to discuss applications and test results. Emphasis was placed on concepts and techniques which show the trade-offs dealing with cost versus performance. The subjects discussed include: (1) strapped down inertial guidance systems; (2) inertial navigation systems for the space shuttle; (3) materials for the inertial navigation systems; (4) gyro stabilized platform applications; (5) inertial system for missile midcourse guidance; and (6) fault isolation and maintenance concepts for inertial navigation systems. For individual titles, see N73-20685 through N73-20717.

**N73-20686** Officine Galileo S.p.A., Florence (Italy)

**STRAPPED DOWN INERTIAL GUIDANCE SYSTEM STUDY**

R. Baldassini Fontana. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 42 p. refs. (For availability see N73-20684 11-21)

The sources and magnitudes of errors occurring in a strapped down environment are discussed. The functions of the accelerometers and gyroscopes in a strapped down system are described. The parameters which must be investigated and defined to evaluate the performance of a stabilized platform are tabulated. The requirements of inertial sensors for maintaining vehicle attitude, velocity, and position are examined. Mathematical models for determining the errors produced by various parameters which affect the inertial system are developed. Diagrams of typical strapdown systems are included. PNF

**N73-20686** Massachusetts Inst. of Tech., Cambridge Charles Stark Draper Lab.

**SUMMARY OF NEW DEVELOPMENTS AT THE DRAPER LABORATORY**

Robert A. Duffy. In AGARD Inertial Navigation Components

and Systems Feb 1973 5 p (For availability see N73-20684 11-21)

Research projects involving the development of inertial guidance systems and components are discussed. The application of inertial guidance to tactical and strategic missile systems is analyzed. The efforts of the laboratory in support of the Apollo project are examined. Fault tolerant design concepts in digital computer construction are advocated as a means of achieving improved reliability. Systems for stabilizing Orbital Astronomical Observatory satellites are reported. Specific systems for lunar exploration, commercial air transportation, oceanography, flight control, and biomedical experiments are briefly discussed. P.N.F.

**N73-20687\*** Massachusetts Inst of Tech., Cambridge Charles Stark Draper Lab

#### FAILURE MANAGEMENT OF MULTIPLE GIMBAL INERTIAL SYSTEMS FOR SPACE SHUTTLE

David W. Dove and Richard A. McKern. In AGARD Inertial Navigation Components and Systems Feb 1973 14 p refs. Sponsored by NASA (For availability see N73-20684 11-21) CSCL 17G

A failure detection and isolation technique for use with four gimbaled inertial measurement units (IMU) is presented. By using simulated boost and entry shuttle trajectories with specific gimbaled IMU models, failure detection thresholds are developed based on red line life dependent requirements and warning thresholds within the red-line thresholds based on expected worst case IMU performance. Using these trajectories, established trajectory threshold, and multiple IMU models, various failure detection and isolation techniques are evaluated for application in both powered and unpowered flight phases. The adequacy of the systems for both attitude and velocity detection methods is evaluated and recommendations for space shuttle applications are made. Author

**N73 20688** Massachusetts Inst of Tech. Cambridge Charles Stark Draper Lab

#### STRAPDOWN INERTIAL GYROSCOPE

Michael S. Sepuppo. In AGARD Inertial Navigation Components and Systems Feb 1973 10 p refs (For availability see N73-20684 11-21)

A miniature single-degree-of-freedom gyroscope has been developed for the application to a strapdown inertial guidance system. This development is based on many years of experience with the design and development of high-performance pendulous integrating gyroscopic accelerometers (PIGA). By utilizing basic design principles of the gyroscopic element contained in the PIGA, which by nature of the PIGA operation presents a slow environment to the gyroscopic element, a strapdown gyroscope evolves which operates and performs exceptionally well under high linear accelerations and high slew rates. This paper describes a strapdown gyroscope that is less than 1.12 inches in diameter by 2 inches in length and weighing under 1/2 pound. The angular momentum is only  $8.5 \times 1,000$  dyne cm sec, which gives it several natural benefits of small size, low power consumption, high reliability, and reasonable cost. To achieve high performance with low angular momentum, low uncertainty torques are required about the output axis of the gyroscope. The design of this strapdown gyroscope involved the systematic identification of each error source coupled with the introduction of subcomponent design principles to reduce these error magnitudes and therefore minimize the consequential sources of uncertainty torque. Author

**N73-20689** Massachusetts Inst of Tech., Cambridge Charles Stark Draper Lab

#### INERTIAL-GYRO TESTING FOR RELIABILITY

Albert P. Freeman. In AGARD Inertial Navigation Components and Systems Feb 1973 10 p (For availability see N73-20684 11-21)

Methods for conducting reliability tests of gyroscopes used with inertial platforms. The types of tests required are defined as: (1) acceptance tests to determine if the gyroscope can meet performance requirements and (2) reliability and/or design verification tests. The acceptance tests are identified to show the parameters which are measured. The design verification tests

are concerned with environmental tests, reliability analyses, and engineering evaluation. A typical reliability test specification is included. P.N.F.

**N73-20690** Litton Systems, Inc., Woodland Hills, Calif  
**P-4, A LOW-COST IMU RESULTING FROM OPTIMUM SIZE DESIGN**

John H. Tamura and John M. Peterson. In AGARD Inertial Navigation Components and Systems Feb 1973 9 p (For availability see N73-20684 11-21)

The P-4 Inertial Measurement Unit development program was undertaken to achieve a low-cost IMU with navigational accuracy performance resulting from optimum size design of inertial instruments and platform. This approach placed a heavy emphasis on simplification and reduction in the number and complexity of individual parts. The cost-size tradeoff studies which were conducted for the inertial components, gimbal set, and system during the design phase are presented and discussed. The result of the development program is an inertial platform of 7.9 inches in diameter and 3.15 inches in length, weighing 1.9 pounds and requiring 25 watts of power. The resulting Inertial Measurement Unit is contained in a single package 3.5 inches by 3.25 inches by 7.25 inches, weighing 6 pounds. Author

**N73-20691** Societe d'Applications Generales d'Electricite et de Mecanique, Paris (France)

#### METHOD OF MEASURING THE INERTIAL QUALITIES OF A QUASI-SPHERICAL ROTOR [METHODE DE MEASURE DES QUALITES INERTIELLES D'UN ROTOR QUASI SPHERIQUE]

L. Camberlain, A. Ceval, and J. C. Silvestre. In AGARD Inertial Navigation Components and Systems Feb 1973 9 p refs. In FRENCH (For availability see N73-20684 11-21)

A method for measuring inertia that is applicable to spherical gyroscope rotors with electric suspension is analyzed. The method permits the principle axis of inertia relative to the center of mass to be determined and allows the relative differences of inertial moments to be measured. Transl. by E.H.W.

**N73-20692** Queen Mary Coll., London (England) Dept of Materials

#### MICROPLASTICITY IN MATERIALS FOR INERTIAL NAVIGATION SYSTEMS

William Bonfield. In AGARD Inertial Navigation Components and Systems Feb 1973 6 p refs (For availability see N73-20684 11-21)

The determination of the friction stress, the microscopic yield stress (the stress to produce a plastic strain of  $2 \times 10^{-6}$ ) and the rate of strain hardening in the microstrain region is described. An evaluation of the influence of some metallurgical variables on these parameters is presented in which particular reference is made to the characteristics of beryllium, aluminum and a copper-beryllium age hardening alloy. The interpretation of the microstrain results is discussed from two standpoints: first, the development of a general understanding of microplasticity, and, second, the application of such concepts to inertial navigation components. Author

**N73-20693** Army Electronics Command, Fort Monmouth, N.J. Avionics Lab

#### RAPID INITIALIZATION OF INERTIAL NAVIGATION SYSTEMS THROUGH PARAMETER ESTIMATION

Joseph A. Desero. In AGARD Inertial Navigation Components and Systems Feb 1973 11 p refs (For availability see N73-20684 11-21)

The problem of rapid initialization of an inertial navigation system using an azimuth wander mechanization is treated in detail. An error model is developed which contains all significant cross coupling terms and inertial component random drifts. Determination of the initial azimuth wander angle is then identified as a parameter estimation problem where the parameter can assume any of a continuum of values (from 0 to 2 pi). Two methods of solving parameter estimation problems currently in

the literature are discussed. One of the methods is then extended to permit time optimal estimation of the initial azimuth angle. The platform controller is developed and the overall system described. Results of a computer simulation are presented.

Author

**N73-20684** Teldix Luftfahrt-Ausrüstungs G.m.b.H. Heidelberg (West Germany)

# INVESTIGATIONS ON THE OPTIMIZATION OF AIDED INERTIAL NAVIGATION SYSTEMS

Rainer S. Sindinger. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 16 p. refs. (For availability see N73-20684 11-21)

The stringent performance requirements for modern, self-contained aircraft navigation systems can only be met by integrated systems combining several independent navigation sensors, like inertial measurement unit, Doppler radar, and radio position fixing devices (e.g. Tacan). Some investigations on the optimization of such integrated navigation systems are discussed. It will be shown that high navigation accuracy can be obtained even with medium-performance sensors by implementation of an optimal estimation and control filter, and by the use of methods reducing the influence of some inertial sensor errors on the system performance. The basic rule for the realization of an effective integrated navigation system is to use sensors with complementary characteristics, but with mutually balanced accuracy.

Author

**N73-20695** Army Missile Command, Redstone Arsenal, Ala. Guidance and Control Directorate

# COMPLIANT SURFACES FOR AIR BEARING GYROS

James V. Johnston. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 8 p. refs. (For availability see N73-20684 11-21)

A development study on a spherical, hydrostatic, compliant bearing for a directional gyro is discussed. The concept of the rubber air bearing and its subsequent development is traced through its analytical analysis and experimental hardware fabrication to the test results. Use of a compliant material for one of the bearing surfaces, which would grip the rigid surface when unpressurized, constitutes the novel concept of self-caging. Included in this paper are the basic design curves developed for the compliant bearing. Use of these curves provides the bearing engineer with the basic tools necessary to design compliant air bearings. Unusual problems encountered in the fabrication and evaluation of rubber bearings are shown and discussed. Areas of further investigation are indicated which would enhance the rubber bearing development technologies.

Author

**N73-20696** CIT Compagnie Industrielle des Telecommunications, Briey-le-Chateau (France). Div. des Essais et des Systemes Inertiels

# GAS HYDRODYNAMIC LANDING GYROSCOPE WITH TWO DEGREES OF FREEDOM. METHOD OF EVALUATING PERFORMANCE [GYROSCOPE A DEUX DEGRES DE LIBERTE SUR PALIER A GAZ HYDRODYNAMIQUE METHODE D'EVALUATION DES PERFORMANCES]

Pierre Leger. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 19 p. refs. In FRENCH (For availability see N73-20684 11-21)

Two principle means developed to measure the functions and performance of a gyroscope with two degrees of freedom are outlined. A mathematical model representing the essential characteristics of the apparatus, given the formulation of parasitic coupling of the gyroscope under constant acceleration, is described. Statistical optimization was used to analyze multi-position effects according to the type of gyroscope and numerous redundancies present in a series of measurements. Probable coefficients of the model and the uncertainties associated with these coefficients are evaluated.

Transl. by E. H. W.

**N73-20697** Teledyne Systems Co., Northridge, Calif.  
**DYNAMICALLY TUNED GYROS IN STRAPDOWN SYSTEMS**  
Robert J. G. Craig. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 26 p. refs. (For availability see N73-20684 11-21)

A review is presented of the basic principles of operation of the dynamically tuned instrument and shows a gyro configuration designed for the strapdown use. Characteristic errors in a multigimbal design are discussed and the basic error models for the gyro, together with its dynamic characteristics, are presented.

Author

**N73-20698** Air Force Avionics Lab., Wright-Patterson AFB, Ohio

# THE EVOLUTION OF ESG TECHNOLOGY

Robert R. Warzynski and Ronald L. Ringo. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 8 p. (For availability see N73-20684 11-21)

Two electrostatic gyro (ESG) navigation systems are described: the gimbaled ESG aircraft navigation system (GEANS) and the strapdown ESG micro navigator (MICRON). The ESG, its drift error sources, the exploratory program that preceded the development of the GEANS and MICRON, and the status of the GEANS and MICRON development are reported.

Author

**N73-20699\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

# PROGRESS IN STRAPDOWN TECHNOLOGY

J. C. Hung (Tenn. Univ., Knoxville) and G. B. Doane, III. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 9 p. refs. (For availability see N73-20684 11-21)

CSCL 17G

An overview is presented of typical inertial grade instrumentation available to mechanize precision strapdown attitude reference systems as well as a novel scheme of redundancy management, if two degree of freedom instruments are used. The instrumentation is divided between conventional and unconventional sensors with some assessment of their readiness included.

Author

**N73-20700** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio

# INERTIAL SYSTEM ENHANCEMENT OF FLIGHT CONTROL

Max L. Lipscomb and Fred D. Smith. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 11 p. refs. (For availability see N73-20684 11-21)

The functions of vehicle flight control to which a quality inertial system will contribute, and in a number of cases make possible, is discussed. The status of programs aimed toward more fully defining and implementing these flight control functions, including all weather landing as well as automatic steering, is outlined with the results achieved to date. Functional requirements which will be levied on the inertial system are listed and examined as to the parameters measured or computed, reliability, criticality relating to flight safety, practicality of the system for broad applications from both simplicity of operation and economical standpoints, and physical aspects. Both established and probable requirements of an acceptable system are noted. The requirements will of necessity stress the fact that such a system is a safety flight item and reliability is extremely critical. A brief survey is presented of the trends and developments toward the systems which will be required to achieve universal integration of inertial navigation system signals into the flight control system functions. Several different types of inertial systems now under development are discussed to illustrate the technology which may yield applicable systems.

Author

**N73-20701** Army Electronics Command, Fort Monmouth, N.J. Navigation Systems Team

# DESIGN OF A KALMAN DERIVED, FIXED, GAIN, HYBRID NAVIGATION SYSTEM

W. R. Light Jr., R. F. Clark, C. T. Elliott, M. J. Fisher, C. J. Galanti, J. A. Knight, and I. Levine. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 10 p. refs. (For availability see N73-20684 11-21)

At present, there exists a major effort to develop cost effective navigation systems for application to U.S. Army aircraft. Major factors involved in the design of one candidate for such an application (a loran/inertial hybrid system) are discussed. The design factors addressed include selection of a measurement processing technique to be used in conjunction with a Kalman filter algorithm and the modification of this algorithm to provide Kalman derived, fixed feedback gains, free of geographic dependence. Relative performance of the fixed gain and Kalman systems is assessed through analysis of data from both Monte Carlo computer simulations and actual flight test. Author

**N73-20702** Steinhil-Lear Siegler A.G., Ismaning (West Germany)

**A THREE AXIS GYRO STABILIZED TORPEDO PLATFORM**  
Gerhard Gerber. In AGARD Inertial Navigation Components and Systems. Feb 1973. 9 p. (For availability see N73-20684 11-21)

The design of a three axis platform is described with dimensions of 190 mm in diameter, 225 mm in length, and a weight of 6 kg with a ready time of approximately 10 seconds. The power consumption is equal or less than 35 watts. The attitude is equal or better than 0.3 degrees in roll and pitch with a drift rate (depending on the gyro) of better than 4 deg/h in azimuth. The platform is supplied with 115 V AC, 3 phase and includes all electronics. Author

**N73-20703** Technische Hogeschool Twente, Enschede (Netherlands)

**DETERMINATION OF SHIPS ORIENTATION FROM ACCELEROMETER SIGNALS**

R. P. Offereins. In AGARD Inertial Navigation Components and Systems. Feb 1973. 9 p. refs. (For availability see N73-20684 11-21)

A method is described for determining the orientation of a ship using only signals from accelerometers and without the use of gyroscopes. Three rotation accelerometers and two translation accelerometers are necessary. They are rigidly attached to the ship. Their signals and the signal of the compass are processed by a digital computer which performs a sort of filtering process to compute continuously the three angles determining ships orientation. These angles may be used for controlling equipment like radar guns etc. The advantage of the method as compared with a solution using gyros is the simple and reliable hardware. The critical point will be the accuracy of measurement of rotation acceleration. The computer program has been tested and now experiments are carried out to test the system with a model of a moving ship. Author

**N73-20704** Marconi Elliott Avionic Systems Ltd. Rochester (England). Inertial Navigation Div.

**THE USE OF A CLUSTER ROTATED INERTIAL SYSTEM, IN A STRIKE AIRCRAFT ENVIRONMENT**

D. G. Harris. In AGARD Inertial Navigation Components and Systems. Feb 1973. 7 p. (For availability see N73-20684 11-21)

The Jaguar inertial system is described which involves the use of spatial commutation of the horizontal inertial sensor errors to achieve the required performance. The development program concerned with the realization of the system is reviewed. A brief review of the theory of cluster rotation and its advantages is followed by description of the way the technique was applied to improve the performance of an existing platform. Other aspects of the inertial navigation system where the design was influenced by the use of the rotation technique are then described. The sequence of laboratory and flight trials during which problems were discovered and the methods for solving the problems are discussed. Author

**N73-20706** Boeing Co., Seattle, Wash.

**DESIGN OPTIMIZATION OF SRAM INERTIAL NAVIGATION AND GUIDANCE**

J. H. Whiting and R. D. Thomas (SRAM System Program Office). In AGARD Inertial Navigation Components and Systems. Feb 1973. 10 p. (For availability see N73-20684 11-21)

Since the AGARD Inertial Navigation Symposium in 1967 and 1968, the short range attack missile (SRAM) has progressed from the design phase into production. The United States Air Force's newest strategic weapon is now entering the inventory and will become operational later this year with the first wing of B-52 aircraft modified to carry it. Navigation, guidance and transfer of alignment techniques which were being developed in 1968 have been incorporated into the weapon system and successfully demonstrated on JD flight tests. A general description of SRAM, unique features of the SRAM inertial navigation and guidance system, and the considerations which led to the final design are presented. Emphasis is placed on in-flight inertial navigation alignment and calibration, and design features which minimize cost. Author

**N73-20706** Bodenswerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany)

**ADVANCED PROCEDURES FOR SELF-ALIGNMENT AND CALIBRATION OF INERTIAL PLATFORMS**

U. K. Krogmann. In AGARD Inertial Navigation Components and Systems. Feb 1973. 18 p. refs. (For availability see N73-20684 11-21)

Starting with the nonlinear and linear model of the IMU in the gravity field of the rotating earth it is shown that the state-vector normally cannot be measured directly. An optimal estimator is necessary to estimate system state at discrete time. Different estimation techniques applicable for alignment and calibration are treated in detail and compared with respect to complexity and efficiency. Closed loop as well as quasi-closed loop techniques are contemplated using Kalman-Filter and weighted least squares. The problem of estimator divergence is discussed briefly. Author

**N73-20707** Institut fuer Flugnavigation, Stuttgart (West Germany)

**PROCEDURES FOR THE ESTIMATION OF THE IN-FLIGHT VERTICAL MISALIGNMENT OF PLATFORMS**

Volkmar Held. In AGARD Inertial Navigation Components and Systems. Feb 1973. 16 p. refs. (For availability see N73-20684 11-21)

Test flight measurements were made with a single-axis inertial platform mounted in a Transall C 160 test aircraft. For additional velocity information the outputs of the Doppler radar were used. The estimation of the platform vertical misalignment is performed in two different ways: with a so-called mean value procedure which needs only the integral of the platform accelerometer output and the appropriate component of the Doppler velocity and with a Kalman filter. The dynamic and statistic values which are necessary to implement the filter are determined from the flight measurements. Different filter models result in dependence on the platform horizontal reference axis orientation relative to the aircraft and on the aircraft acceleration according to gusts. The results of the platform misalignment estimation show that the application of a Kalman filter procedure leads in all treated cases to the best estimation accuracy if an additional velocity measurement is used. If no Doppler velocity measurement is available for the estimation, the errors are so large that it is not worthwhile to apply the sophisticated Kalman filter. Author

**N73-20708** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Braunschweig (West Germany). Inst. fuer Flugfuehrung

**THE MODELLING ERROR SENSITIVITY OF DIGITAL FILTERS FOR THE ALIGNMENT OF INERTIAL PLATFORMS**

Heinz Winter. In AGARD Inertial Navigation Components and Systems. Feb 1973. 15 p. refs. (For availability see N73-20684 11-21)



The effect of incorrect or incomplete modelling of a typical inertial platform on sub-optimal filters on the alignment and calibration accuracy is analyzed. Closed-loop alignment with a 13-dimensional Kalman filter and open-loop alignment with a 4-dimensional regression filter are considered. Simplifications of the precomputed gain matrix and a fairly simple controller for closed-loop alignment are analyzed with respect to their effect on the alignment accuracy. It is shown that the modelling errors in the 4-dimensional regression filter lead to increasing uncertainty in the platform state estimation after a certain estimation time. The limitation of the azimuth alignment accuracy caused by the east gyro drift is discussed for different drift correlation times between 1.5 seconds and infinite time and is compared with the steady state azimuth alignment error in a third order gyrocompassing loop. Author

**N73-20709** Ferranti, Ltd. Edinburgh (Scotland). Inertial Systems Div.  
**GYRO CHARACTERISTICS FOR RAPID GYRO-COMPASSING**  
K. R. Brown and D. Anderson. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 18 p. ref. (For availability see N73-20684 11-21)

Inertial navigation system alignment, of course, includes finding north by gyrocompassing, and around 2.5 minutes must be met if the overall reaction time of the aircraft is not to be limited by the system. It is found that for all practical purposes the equipment must be switched on from cold and this necessitates the use of the inertial instruments before they reach their designed operating temperature. The results are given of a program of work over many years, to determine the parameters of single-axis floated gyroscopes, when used in inertial systems requiring rapid reaction under these conditions. New parameters of gyro drift have been obtained, and the new technique of system operation based on these is outlined. The performance obtained with an inertial navigation system using these techniques is given to illustrate the benefits to be gained. Author

**N73-20710** LTV Aerospace Corp. Dallas, Tex.  
**A-7 AIRCRAFT AIRBORNE, GROUND, AND SHIPBOARD INERTIAL NAVIGATOR ALIGNMENT METHODOLOGY AND RESULTS**  
M. G. Johnson, Jr. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 10 p. (For availability see N73-20684 11-21)

The A-7D aircraft navigation system is described and in particular the alignment method. The particular functions which the system performs are outlined. The alignment techniques are described in a basic fashion without delving into a detailed derivation. Finally, some experience gained during the A-7 program is presented along with test results. Author

**N73-20711** Norwegian Defence Research Establishment, Kjeller Div. of Electronics.  
**PENGUIN MISSILE INERTIAL NAVIGATION SYSTEM. DESIGN CONSIDERATION FOR MIDCOURSE GUIDANCE**  
H. K. Johansen. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 13 p. (For availability see N73-20684 11-21)

The midcourse guidance of the Penguin ship to ship missile requires an inertial navigation system for attitude reference and position computation. The INS has a three axis platform with resolver outputs to the guidance system and seeker head. The cross-track position is computed by analog electronics. Later versions also incorporate down range navigation electronics. The mechanical design emphasizes simplicity in assembling and maintenance by making use of a complete package design. A rapid initialization technique for use on board small fast patrol boats is described. In azimuth resolver slaving is used and leveling is performed by using the platform accelerometers and by compensating for the ship horizontal accelerations. A modified tangent plane navigation scheme is used in the flight mode. Navigator accuracy better than 200 m at 25 km has been demonstrated. Results from error simulations and results from a rocket sled test program are shown. Author

**N73-20712** Royal Aircraft Establishment, Farnborough, (England) Avionics Dept.  
**FAULT DETECTION POSSIBILITIES IN A SYSTEM EMPLOYING KALMAN FILTERING**  
F. Gregson. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 10 p. refs. (For availability see N73-20684 11-21)

Kalman filtering is coming into use as a means of mixing sensor information in an integrated navigation system. Use of the technique, implying knowledge of the errors in the system and their statistics, should provide a basis for fault detection. The report quotes the basic Kalman filtering equations and discusses the indirect implementation normally used in airborne navigation applications. Types of faults in the sensors are categorized according to the way in which they would affect the operation of Kalman filtering. Criteria are established for detecting each category of fault. These are discussed with reference to a Doppler-inertial navigation system. The methods proposed for the detection of faults are shown to be relevant to the problem or divergence encountered in some Kalman filter implementations. It is concluded that it should be possible to detect faults. Location however may not be possible. Author

**N73-20713** Singer Co., Little Falls, N.J. Aerospace and Marine Systems Group.  
**FAULT ISOLATION AND MAINTENANCE CONCEPTS OF AN ADVANCED INERTIAL NAVIGATION SYSTEM**  
Francis H. Murphy. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 9 p. (For availability see N73-20684 11-21)

The design concepts, hardware characteristics, and system tradeoffs are described which have been considered for a self-contained advanced inertial navigation system. Included in this system is an automatic self-annunciating fault isolation capability. The system is packaged in a single LRU and has been organized to be modular in construction with fault annunciation to both the module level for flight line level maintenance and to the functional circuit hybrid chip at the intermediate level. Details are presented on the various built-in test functions, as well as validation of the built-in test hardware by utilization of the BITE-on-BITE concept. Software monitoring is discussed, including built-in flight line self-test, calibration and in-flight performance monitoring utilizing existing redundancy within the platform subsystem. The utilization of a calibration computer card is also discussed. This card, an interchangeable replacement for the operational computer card, is utilized to perform periodic calibration of the platform subsystem without the need for any additional external support calibration equipment. The report concludes with a summary of the methods used to fault isolate and the maintenance action required at the various operational levels. Author

**N73-20714** Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France).  
**ACTIVITIES OF LRBA IN THE INERTIAL DOMAINE (ACTIVITES DU LRBA DANS LE DOMAINE DE L'INERTIE)**

Jean Moret and Guy Cally. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 12 p. In FRENCH. (For availability see N73-20684 11-21)

The role of LRBA in inertial affairs relative to French military programs and the methods used by the facility to study these systems are briefly outlined. Qualification tests of accelerometer systems for ballistic engine guidance, in environments simulated on a centrifuge, are discussed in detail.

Transl. by E. H. W.

**N73-20715** Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France).  
**DETERMINATION OF NONLINEAR ACCELEROMETERS BY A METHOD OF DIFFERENTIAL TESTS (DETERMINATION DES NON LINEARITES D'ACCELEROMETRES PAR UNE METHODE D'ESSAIS DIFFERENTIELS)**

Jean Moret and Guy Cally. In AGARD Inertial Navigation Components and Systems. Feb. 1973. 8 p. In FRENCH. (For availability see N73-20684 11-21)

A differential test method used to evaluate the quality and performance of nonlinear accelerometers is described. Advantages of the method over classical methods, measurement errors, and the results obtained are given. *Transl by EHW*

**N73-20716** Royal Aircraft Establishment, Farnborough (England) Avionics Dept

**DATUM POSITIONS AND VELOCITIES FOR THE EVALUATION OF INERTIAL NAVIGATION SYSTEMS**

R F Stokes and S G Smith. In AGARD Inertial Navigation Components and Systems. Feb 1973. 21 p. (For availability see N73-20684 11-21)

The methods are described which were employed to obtain datum position and velocity information for use in evaluating inertial navigation systems with a performance of around 1 n mile/h. The methods were designed to permit evaluations on a world-wide basis using whatever sources of position information are available. These are usually two inertial navigation systems, a Doppler dead reckoning position, range-range Tacan or DME, Decca, and Ioran C. The datum produced has to be accurate enough, and in a suitable form, for use in trying to identify the major sources of system error in the inertial navigation system under test. A lower accuracy datum, only suitable for use in statistical analyses, is also described. Various examples are given of the accuracies of the methods, of the quality of inertial navigation system error information obtained, and of the errors obscured in Tacan, Decca and Ioran C fixes. The methods for identifying error sources are related to the type of datum obtained. The virtues of range-range Tacan, Decca, and Ioran C for providing fixes for these types of evaluation are also discussed. *Author*

**N73-20717** Aerospace Guidance and Metrology Center, Newark Air Force Station, Ohio. Plans and Management Staff Office

**LIFE CYCLE COST ANALYSIS OF INERTIAL SYSTEMS FOR AIRCRAFT AND AIR TO SURFACE MISSILES**

Donald L Hardy Jr and Russell M Genet. In AGARD Inertial Navigation Components and Systems. Feb 1973. 5 p. refs. (For availability see N73-20684 11-21)

Life cycle cost analysis of Inertial Navigation Systems (INS) is becoming more significant to all users today as performance goals more closely achieve their objectives. Cost of ownership models and analyses were developed that contribute to current and future assessments of this important area. These analyses are based on an extensive accumulation of inertial systems data. The current analyses include a critical assessment of the current model and its data, a taxonomic analysis of INS applications, and a sensitivity analysis of all input model parameters. These analyses have led to development of new models which will more accurately predict the cost of ownership of a given inertial system. The primary usefulness of the models will be for (1) generalized analysis of, and (2) discrimination between, the cost of ownership of aircraft and air to surface missile inertial systems. Specific references are made to the most sensitive parameters of any cost of ownership analysis concerning inertial navigation systems. These parameters are of great use in knowing how little data is actually needed to make management and technical discussions. The types of decisions and applications managers and design personnel need to make concerning inertial systems are also outlined. *Author*

**N73-23689\*** Advisory Group for Aerospace Research and Development, Paris (France)

**AIR TRAFFIC CONTROL SYSTEMS**

Apr 1973. 371 p. refs. In ENGLISH and FRENCH. Presented at the 14th Meeting of the Guidance and Control Panel of AGARD, Edinburgh, 26-29 Jun 1972. (AGARD CP-105). Avail. NTIS. HC \$20.75

The proceedings of a conference on air traffic control developments and procedures are presented. The subjects discussed involve the following: (1) control concepts; (2) automation; (3) area and enroute navigation; (4) terminal navigation and control; (5) landing guidance; (6) surveillance; (7) communications; (8) collision avoidance; and (9) integrated communication, navigation and identification system. For individual titles, see N73-23690 through N73-23721.

**N73-23690** Electronic Systems Div., Bedford, Mass.  
**STATUS AND TRENDS IN MILITARY AIR TRAFFIC CONTROL SYSTEMS**

Albert R Shietz, Jr. In AGARD Air Traffic Control Systems. Apr 1973. 3 p. (For availability see N73-23689 14-21)

The status and trends in military air traffic control systems are discussed. The air navigation facilities operated by U S Military Forces are described. The mission of the Air Defense Control System is explained. The development of automated air control systems, airborne search radar, and integrated communication, navigation, and identification systems is reported. *Author*

**N73-23691** Eurocontrol Agency, Brussels (Belgium)  
**AIR TRAFFIC CONTROL IN THE EUROCONTROL AREA**

G M Trow. In AGARD Air Traffic Control Systems. Apr 1973. 18 p. (For availability see N73-23689 14-21)

The organization and operation of the Eurocontrol area air traffic control system are discussed. The member nations comprising the organization are identified. The accomplishments of the organization are presented. The problems peculiar to European flights because of national sovereignty are analyzed. The development of an improved system of air traffic control is reported. Maps of the Eurocontrol area of operation are included. *Author*

**N73-23692** Wilcox Electric Co., Inc., Kansas City, Mo.  
**DECISIONS FOR THE 70'S**

Robert J Shank. In AGARD Air Traffic Control Systems. Apr 1973. 15 p. (For availability see N73-23689 14-21)

The nature of the air traffic control system and procedures during the 1970's are almost completely determined by decisions made during the past twenty years. A brief review of this already-determined baseline system and its operation is included, and a set of objectives for the future and guiding principles will provide a background for the major decisions now confronting the world air traffic control community. The important proposed changes or improvements in the areas of surveillance, navigation, communications, collision avoidance, and instrument landing are examined, and the major issues for decision are proposed. *Author*

**N73-23693** National Aerospace Lab., Amsterdam (Netherlands)  
**ATC AUTOMATION, PRESENT AND FUTURE**

C G H Scholten. In AGARD Air Traffic Control Systems. Apr 1973. 5 p. refs. (For availability see N73-23689 14-21)

A number of design principles in which future air traffic control systems should differ from present systems in order to cope with increased air traffic demands are discussed. The principles are that available air space and airports should be used in as flexible a manner as possible by using computers and that improved data links between ground and air will be required for pilot-computer communication. The need for a back up system in the event of complete computer failure to allow controllers to clear existing traffic safely is proposed. *Author*

**N73-23694** IBM Italia, Rome  
**AUTOMATION OF AIR TRAFFIC CONTROL IN ITALY, ROME CONTROL AREA**

Camillo Martucci and Bruno Tincani. In AGARD Air Traffic Control Systems. Apr 1973. 10 p. (For availability see N73-23689 14-21)

The physical structure and operative unit organization of the Rome, Italy air traffic control system are discussed. The automation of the system is described to include the functions and capabilities. The phases in which the automated system is being implemented are reported. Diagrams of the system components and network to show the operation of the system are provided. *Author*

**N73-23695** Centre d'Experimentation de la Navigation Aeronautique, Orly (France)  
**THE SAVVAN. MEANS FOR INSPECTION BY VOR AND DME [LE SAVVAN. MOYEN D'INSPECTION DES VOR ET DES DME]**

Gilbert Montel. In AGARD Air Traffic Control Systems. Apr 1973. 11 p. In FRENCH. (For availability see N73-23689 14-21)

An evaluation is presented of the effectiveness of the E-4/VAN (automatic system for verification of navigation aids in flight) in locating and controlling high altitude aircraft. The system responds to signals from VOR and DME onboard the aircraft. Signals are registered on a magnetic band where they are processed according to a pre-established computer program. Along with the magnetic band, the system has logic elements and 12 receivers. Transl. by E.H.W.

**N73-23690** Federal Aviation Administration, Washington, D.C.  
**STATUS AND TRENDS IN CIVIL AIR TRAFFIC CONTROL SYSTEMS**

Gustav E. Lundquist. In AGARD Air Traffic Control Systems. Apr. 1973. 5 p. (For availability see N73-23689 14-21)

The status and trends on civil air traffic control systems are discussed. The use of automation programs to increase air traffic control safety by providing the air traffic controller with better information on which to base decisions is examined. The development of a network of computers, displays, and communications which will process, store, and distribute instrument flight rules is reported. The operation of the system is described by illustrations and block diagrams. Author

**N73-23697** Singer-Kearfott, Fairfield, N.J.  
**AREA NAVIGATION: COST VERSUS OPERATIONAL BENEFITS**

Jefferson Z. Amacker. In AGARD Air Traffic Control Systems. Apr. 1973. 9 p. refs. (For availability see N73-23689 14-21)

Cost, complexity, and cockpit workload were compared for seven potential area navigation system configurations. Cockpit workload was found to be minimum for the very simple and most sophisticated systems. However, the sensitivity of the cost parameter is such that it increases dramatically with system complexity with relatively little gain in operational benefit. A detailed study of the Mark I, Mark 13, and ATA Operations Committee requirements document discerned that almost all required operational functions could be accomplished with minimum systems. Author

**N73-23698** Litton Systems, Inc., Woodland Hills, Calif. Aero-Products Div.

**AIRBORNE AREA NAVIGATION EQUIPMENT**

C. S. Bridge and R. J. Holm. In AGARD Air Traffic Control Systems. Apr. 1973. 13 p. (For availability see N73-23689 14-21)

A broad base of area navigation equipment, manufacturers and users exists. Types of equipment extend from simple adaptation of VOR to triple inertial systems with multiple radio position inputs and digital computer processing. Air transport equipment is grouped into Mark I, Mark II and Mark 13 systems which are described. Area navigation systems are based upon, or augmented by, air data, VOR, Doppler, inertial, Loran A/C, Omega, and satellite. Demonstrations and performance in recent flight tests show state-of-the-art for area navigation systems with consideration of projected requirements. Examples of enroute navigation, vertical navigation, terminal area and landing are shown. Controls, pictorial displays, automatic data entry and data link are discussed. Author

**N73-23699** Systems Control, Inc., Palo Alto, Calif.  
**AN ATC/SURVEILLANCE MODELING APPROACH FOR SPECIFYING LANE SEPARATION STANDARDS**

J. S. Tyler, D. E. Stepper, and J. A. Sorensen. In AGARD Air Traffic Control Systems. Apr. 1973. 12 p. refs. (For availability see N73-23689 14-21)  
(Contract DOT-TSC-260)

The reduction in separation standards for both domestic and oceanic air routes because of increased travel demand is discussed. The overall problem of relating lane separations to safety for different navigation systems, surveillance systems, and air traffic control procedures are considered. A model is described which has the same general input/output format as the Reich model that has been used for specifying North Atlantic route separations. Numerical results are presented to show the impact of inertial navigation systems and satellite surveillance on the separation standards and safety for the North Atlantic route structure. Author

**N73-23700** Aerospace Systems, Inc., Burlington, Mass.  
**ANALYSIS OF TERMINAL ATC SYSTEM OPERATIONS**  
Richard B. Noll, John Zvara, and Robert W. Simpson (MIT). In AGARD Air Traffic Control Systems. Apr. 1973. 15 p. refs. (For availability see N73-23689 14-21)  
(Contract DOT-TSC-103)

The effects of automation in terminal air traffic control are analyzed with respect to the impact of the automation on the controller. The present air traffic control system based on radar information and manual techniques is discussed and compared with an advanced system which uses a computer to generate alphanumeric radar displays and automated features. A typical control operation is presented to demonstrate controller activity in both the present and an advanced system. ARTS I is used to represent the advanced air traffic control system. The principal features of ARTS I are described and the interface of the controller with the computer and the display equipment is discussed. Author

**N73-23701\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.  
**AN ANALYTIC STUDY OF NEAR TERMINAL AREA OPTIMAL SEQUENCING AND FLOW CONTROL TECHNIQUES**

Stephen K. Park, Terry A. Straeter, and John E. Hogge. In AGARD Air Traffic Control Systems. Apr. 1973. 18 p. refs. (For availability see N73-23689 14-21)

Optimal flow control and sequencing of air traffic operations in the near terminal area are discussed. The near terminal area model is based on the assumptions that the aircraft enter the terminal area along precisely controlled approach paths and that the aircraft are segregated according to their near terminal area performance. Mathematical models are developed to support the optimal path generation, sequencing, and conflict resolution problems. Author

**N73-23702** Air Line Pilots Association, International, Washington, D.C.  
**A REAL WORLD SITUATION DISPLAY FOR ALL WEATHER LANDING**

J. L. DeCelles, E. J. Burke, and Ken Burroughs. In AGARD Air Traffic Control Systems. Apr. 1973. 9 p. (For availability see N73-23689 14-21)

A flight data display for use in aircraft approach and landing under all conditions of visibility is described. The device provides airborne self-contained glide path guidance for use in visual flight conditions. In its most sophisticated form it provides total information for manual landing or monitoring automatic landing and roll-out during reduced visibility. It is stated that the heads up display symbology similar to that described is urgently required for see-to-land approaches and will be essential for pilot acceptance of automatic landings in actual nonvisual conditions. Author

**N73-23703** Royal Aircraft Establishment, Bedford (England)  
**Blind Landing Experimental Unit**  
**THE INFLUENCE OF THE FUTURE LANDING GUIDANCE SYSTEM ON INTEGRATION OF SHORT TAKE-OFF AND LANDING AND CONVENTIONAL AIR TRAFFIC AT A**

**MAJOR AIRPORT**

Nigel H. Hughes. In AGARD Air Traffic Control Systems. Apr. 1973. 17 p. refs. (For availability see N73-23689 14-21)

Some of the benefits to air traffic control which may result from deploying landing guidance systems are identified. The characteristics of short takeoff and landing aircraft intercept of the instrument landing system localizer and final approach path are studied and the final approach geometry is established. STOL approach sequencing requirements are defined and sequencing geometry suggested. The ability of nonvisual approach and landing guidance systems to ease air traffic control problems is discussed. Avionics developments which are required to allow aircraft to take advantage of future landing guidance systems are described. Author

**N73-23704 Army Electronics Command, Fort Monmouth, N.J.  
US ARMY AIR TRAFFIC MANAGEMENT NOW THROUGH 1980**

Charles Grossman and Thomas E. Daniels. In AGARD Air Traffic Control Systems Apr. 1973 11 p (For availability see N73-23689 14-21)

The requirements of an air traffic management system which will be capable of providing for the safe operation of large numbers of aircraft under instrument meteorological conditions (IMC) and thus afford the commander maximum utilization of his combat capability within reasonable constraints of money and equipment, a totally integrated ground and airborne system, are discussed. The requirements are based upon the assumption that the Army will continue to exploit and expand the air mobility concept in the future. In order to accrue the maximum benefits from such a concept the field commander must be afforded the means to effectively use his aircraft with minimum constraints. The absence of such a system currently precludes effective field exploitation of Army aircraft under adverse weather and visibility conditions, and furthermore precludes the onset of operations until weather predictions give reasonable assurance of resupply/evacuation. Author

**N73-23706 Honeywell, Inc., Minneapolis, Minn. Government and Aeronautical Products Div.**

**FUNCTIONAL DESIGN OF MICROWAVE LANDING SYSTEM (MLS) AIRBORNE EQUIPMENT AS INFLUENCED BY GROUND EQUIPMENT CONFIGURATION AND AIRCRAFT TYPE**

Donald N. Carlson and Charles L. Seacord. In AGARD Air Traffic Control Systems Apr. 1973 10 p refs (For availability see N73-23689 14-21)

A description of a proposed microwave landing system (MLS) is presented, with particular emphasis on the functional design requirements of the airborne equipment. This system has the potential of meeting the expanded, more precise, and more complex needs generated by a growing aircraft population consisting of both conventional and unconventional (V-STOL) types. A modular approach to both ground and airborne equipment is identified as a means of achieving desired flexibility and low cost required for a truly universal system serving the full spectrum of user aircraft and aircraft types. Elements of the ground system are identified and their influence on the nature of the transmitted signal is described. Author

**N73-23708 ITT Gilfillan, Inc., Van Nuys, Calif.  
THE PERFORMANCE OF THE DOPPLER MICROWAVE LANDING SYSTEM IN A MULTIPATH ENVIRONMENT**

R. A. Roosen and L. L. Sanders. In AGARD Air Traffic Control Systems Apr. 1973 9 p (For availability see N73-23689 14-21)

The success of the Doppler microwave landing system in meeting the multipath challenge is described. Techniques which can be used to eliminate the effects of multipath are described. The various multipath sources are listed together with the specific requirements for each. Performance data is given which has been gathered from three sources: (1) computer simulation, (2) laboratory tests of an equipment model, and (3) field tests on two experimental Doppler systems. The data indicates that the Doppler MLS, utilizing the simplest form of signal processing, namely, a filter and zero crossing counter, may be adequate under limited accuracy and siting conditions. For performance in heavy multipath, some form of narrowband device will probably have to be employed in order to satisfy the accuracy and minimum coverage angle requirements. Author

**N73-23707 Informasjonskontroll A/S, Asker (Norway)  
LANDING GUIDANCE SYSTEM: HERMES**

Nils Holme. In AGARD Air Traffic Control Systems Apr. 1973 8 p (For availability see N73-23689 14-21)

The basic principles of the landing guidance system Hermes are described. The system is based on the establishment and detection of a coded pattern of gamma radiation from radioactive sources. This principle offers a remarkable combination of high

accuracy, extreme reliability and low cost, especially when applied to the final approach and runway for conventional/short takeoff and landing operations. The ground installation is purely mechanical, with no moving parts. All information is air-derived. Author

**N73-23708 Royal Aircraft Establishment, Farnborough (England). Radio Dept.**

**A FORWARD AREA HOMING AND LANDING GUIDANCE CONCEPT FOR MILITARY AIRCRAFT**

Ian M. Hunter. In AGARD Air Traffic Control Systems Apr. 1973 8 p (For availability see N73-23689 14-21)

The characteristics of a forward area homing and landing guidance concept for military aircraft are discussed. The relative advantages of air-derived and ground-derived concepts are compared. It is concluded that a pure air-derived system cannot meet the military requirements. The development of a hybrid solution is proposed. Author

**N73-23709 Aerospace Corp., Los Angeles, Calif. Development Planning Div.**

**THE POTENTIAL OF A SYSTEM OF SATELLITES AS A PART OF AN AIR TRAFFIC CONTROL SYSTEM**

P. M. Diamond. In AGARD Air Traffic Control Systems Apr. 1973 17 p (For availability see N73-23689 14-21)

The air traffic control (ATC) performance potential of satellite systems utilized in a data acquisition and communications role within a continental United States (CONUS) ATC system is discussed. The unique properties of satellite-based relays provide the only viable means of achieving complete coverage to ground level of the entire airspace, coupled with uniform and highly accurate surveillance position fixing. Position determination, identification, flow control, and collision avoidance functions can be implemented through the use of regional centralization of ground computation, resulting in important benefits to the utilization of the airspace and adaptability of the ATC system. It is shown that the concept of intermittent positive control (IPC) requires aircraft speed/acceleration restrictions and leads to the requirement for surveillance accuracies of 100 to 200 ft within the densely populated regions of airspace expected in the 1980s. A class of satellite systems is described which offers the requisite performance for both commercial carriers and general aviation with low anticipated costs of aircraft equipment. Author

**N73-23710 Service Technique de la Navigation Aérienne, Paris (France).**

**TAM-TAM SYSTEM (SYSTEME TAM-TAM)**

Jacques Louet. In AGARD Air Traffic Control Systems Apr. 1973 11 p. In FRENCH (For availability see N73-23689 14-21)

The TAM-TAM (automatic transmission of messages of air traffic by multiplex) system as a possible data link in air-ground air transmission during oceanic, continental, and terminal control area flight is discussed. Problems encountered and solutions to those problems are included. Translated by E.H.W.

**N73-23711 Mitre Corp., Bedford, Mass.  
DERIVATION OF A WIDE AREA POSITION LOCATION CAPABILITY USING A SYNCHRONIZED TIME DIVISION MULTIPLE ACCESS COMMUNICATION SYSTEM**

Victor A. DeMarines and R. L. Thompson (ESD). In AGARD Air Traffic Control Systems Apr. 1973 10 p ref (For availability see N73-23689 14-21)

A concept for the use of a high bandwidth time division communications system to provide a ground based, wide area position location system is presented. General principles upon which the system is based and a discussion of computational techniques employed are covered. A discussion of system behavior as a function of system and random errors caused by individual element position uncertainty and geometric effects is included. Control mechanisms required to produce stable and reliable performance are also described. Results of a computer simulation are presented to provide estimates of capability under various conditions and to establish the system performance envelope. Author

**N73-23712** Radio Corp of America, Van Nuys, Calif. Electromagnetic and Aviation Systems Div

**SECANT: A SOLUTION TO THE PROBLEM OF MID-AIR COLLISIONS**

J L Parsons *In* AGARD Air Traffic Control Systems Apr 1973 11 p ref (For availability see N73-23689 14-21)

The principal characteristics of SECANT, a system for the separation and control of aircraft using non-synchronous Techniques, are described. This cooperative, transponding collision-avoidance system, designed to be compatible within the entire aviation community, is capable of accommodating the dense air traffic anticipated for the 1980s and beyond. It makes available to the pilot evasion or escape maneuvers in any direction - vertical, horizontal, or a combination. SECANT helps the pilot to avoid mid-air collisions by transmitting probe, and receiving replies with a 1 microsecond pulse at 1000 pulses per second on 24 different frequencies. Various discriminants are used to eliminate undesired signals, and the false alarm rate is near zero. Author

**N73-23713** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**A FRENCH COLLISION: AVOIDANCE SYSTEMS OF TIME-FREQUENCY TYPE. CRITICAL ANALYSIS OF TEST RESULTS**

Roland Moreau *In* AGARD Air Traffic Control Systems Apr 1973 9 p refs *In* FRENCH, ENGLISH summary (For availability see N73-23689 14-21)

Performance tests of a system for air traffic control and collision avoidance are discussed. The system is described and the method of operation is outlined. The precision obtained is analyzed and compared with established standards. Modifications of the signal format are examined. Problems raised by the introduction of the new air traffic control system are reported.

Author

**N73-23714** Royal Air Force Inst of Aviation Medicine, Farnborough (England)

**HUMAN FACTORS PROBLEMS IN CONFLICT DETECTION AND RESOLUTION**

V D Hopkin *In* AGARD Air Traffic Control Systems Apr 1973 8 p ref (For availability see N73-23689 14-21)

Conflict detection and resolution as human factors problems in air traffic control are discussed. It is contended that this assumption is probably incorrect, primarily because of the large differences in urgency, information, procedures and facilities in various phases of flight. The controller's responses depend on the confidence he has in the data available to him, and on his knowledge of how accurate it is likely to be. Automated aids may not be properly used if they include no indication of the accuracy, quality and comprehensiveness of the data on which automated computations are being made. Relevant research methods for human factors studies on conflict detection and resolution are indicated.

Author

**N73-23715** Ferranti, Ltd., Bracknell (England) Digital Systems Div

**PROBLEMS INVOLVED IN ATC AUTOMATION**

David L Stoddart *In* AGARD Air Traffic Control Systems Apr 1973 11 p (For availability see N73-23689 14-21)

The two major problems involved in ATC automation, suitable man-machine interfaces and system reliability, are considered. These problems are placed in perspective by examining the need for automation and by considering the information required by the controller, and how this should be displayed. Suggested man-machine interfaces are examined, including synthetic plan displays, tabular display, touchwires, keyboards, rolling balls and light pens. The operational and technical advantages and disadvantages of these devices are discussed. The problem of reliability is introduced and the need for fail safe systems explained. Various methods of achieving reliability are considered, including triplicated hardware and systems having preferred and reconfigured functional organization. The implications of these systems are discussed and a system design suggested.

Author

**N73-23716** Defence and Civil Inst of Environmental Medicine, Downsview (Ontario)

**THE MAN-COMPUTER INTERFACE PROBLEM IN TERMINAL AUTOMATION**

Leslie Innes *In* AGARD Air Traffic Control Systems Apr 1973 6 p refs (For availability see N73-23689 14-21)

The main concern in the several large air traffic control automation programs which have been implemented has been the provision of information to the controller in a more accurate and more easily assimilable form. The aim was, if not to reduce the controller's workload, to at least keep it within acceptable limits. Experience with these systems to date is reviewed, and the conclusion reached that in few instances has this aim been achieved. Without adequate isolation of the controller from the requirement to continually interact with the computer, workload is inevitably increased to an unacceptable degree, due to the additional tasks imposed on the controller by the demands of the automated aspects of the system. The development of the Canadian Forces automated terminal control concept involved evaluation of several methods of simplified man-computer interaction, carried out within constraints imposed by limited available manpower in the controller trade, and limited funding for the program. A solution has been developed which appears to adequately act as a compromise between these conflicting requirements.

Author

**N73-23717** Laboratoire Central de Recherches Thomson-CSF, Orsay (France)

**INTEGRATION OF COMMUNICATION FUNCTIONS, NAVIGATION, IDENTIFICATION, AND TRAFFIC CONTROL (INTEGRATION DES FONCTIONS DE COMMUNICATION, DE NAVIGATION, D'IDENTIFICATION ET DE CONTROLE DE TRAFIC)**

Lj Milosevic and P Mollie (Service Tech des Telecomms de l'Air) *In* AGARD Air Traffic Control Systems Apr 1973 11 p *In* FRENCH (For availability see N73-23689 14-21)

The economic aspects of replacing separate aircraft landing and anticollision equipment with an integrated time-frequency system are discussed in detail. A comparison was also made of the relative cost value of replacing equipment mounted on the aircraft.

Transl by EHW

**N73-23718** Department of Transportation, Washington, D C  
**SATELLITE CONSIDERATIONS IN FUTURE AIR TRAFFIC CONTROL SYSTEMS**

D E Findley *In* AGARD Air Traffic Control Systems Apr 1973 9 p (For availability see N73-23689 14-21)

A program for improving the air traffic control system of the United States is discussed. The program is involved with deployment and implementation of major improvements for certain enroute and terminal area air traffic control functions. Development efforts are proposed for the following subjects: (1) traffic surveillance, (2) conflict prediction, (3) resolution and avoidance, (4) landing guidance, and (5) automation of air traffic control functions. The background for the formulation of a concept of the air traffic control system for the 1980 time period and beyond is considered. Emphasis is placed on the use of artificial satellites to meet the air traffic demands.

Author

**N73-23719** TRW Systems Group, Redondo Beach, Calif  
**CONCEPTUAL ANALYSIS OF ICNI SYSTEMS**

J H Craigie *In* AGARD Air Traffic Control Systems Apr 1973 7 p refs (For availability see N73-23689 14-21)

The development of an improved communications, navigation and identification (ICNI) system for command and control, air traffic control, and mission execution is discussed. The program is mainly directed toward the requirements of four major Air Force Commands. The special requirements for each type of Air Force mission are analyzed to show the variations required in the proposed system.

Author

N73-23720 Mitre Corp., Bedford, Mass.

**A PRACTICAL DESIGN OF AN ICNI SYSTEM**

C. Eric Ellingson / In AGARD Air Traffic Control Systems Apr. 1973 14 p. (For availability see N73-23689 14-21)

The key factors which have resulted in the proliferation of communications, navigation, and identification equipment in aircraft are discussed. The advantages of interconnective communications capability and common position location capability in reducing complexity of the system while improving operational capability are examined. A specific candidate communication system is proposed and its capabilities are analyzed. Author

N73-23721 Office of the Secretary of Defense (Research and Engineering), Washington, D.C.

**INTEGRITY OF ICNI SYSTEMS**

Robert Lytle Linden / In AGARD Air Traffic Control Systems Apr. 1973 3 p. (For availability see N73-23689 14-21)

An analysis of integrated communications, navigation, and identification systems for aircraft operation is presented. Advances in electronics solid state devices, logic circuits, and discrete function modules are described to show application to systems integration. The anticipated improvements in operational capability through system integration are analyzed. Author

N74-14346# Advisory Group for Aerospace Research and Development, Paris (France)

**TESTING PHILOSOPHY AND METHODS OF GUIDANCE AND CONTROL SYSTEMS AND SUBSYSTEMS**

Oct 1973 210 p. refs. Partly in FRENCH and in ENGLISH (AGARD-LS-60) Avail NTIS HC \$12.50

The proceedings of a conference on performance testing guidance and control systems for aircraft and spacecraft are presented. The subjects discussed are (1) vertical acceleration tests, (2) centrifuge testing of inertial systems, (3) altitude control unit for sounding rockets, (4) evaluation of electro-optically aided space navigation systems, (5) standardization of software and hardware for test systems, (6) testing of aircraft navigation systems with a high precision reference, and (7) inertial guidance system tests using rocket propelled sleds. For individual titles, see N74-14348 through N74-14358

N74-14348 Central Inertial Guidance Test Facility, Holloman AFB, N.Mex.

**INTRODUCTORY REMARKS: TEST TECHNOLOGY TRENDS**

Martin G Jaenke / In AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 3 p. (For availability see N74-14345 05-21)

The trends and approaches taken to solve the problems involved in testing components of inertial navigation systems are discussed. The activities of a test facility are described and importance of reliability analysis as a part of the performance tests is emphasized. The aspects of systems testing which are analyzed are (1) test accuracy, (2) test stimuli, (3) test dynamics, and (4) test efficiency. Author

N74-14347 Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France)

**PIGA: ACCELERATION TESTS ON VERTICAL 10G, 3 HERTZ TABLE**

Michel Corset / In AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 15 p. refs. (For availability see N74-14345 05-21)

The characteristics of pendulous gyro accelerometers and methods for conducting vertical acceleration tests are discussed. Mathematical models are developed to describe the primary elements of gyro accelerometer testing. Block diagrams of the test equipment and components are provided. The problems and procedures for conducting acceleration tests on a centrifuge and vibration tests are explained. Author

N74-14348 Central Inertial Guidance Test Facility, Holloman AFB, N.Mex.

**INERTIAL GUIDANCE SYSTEM CENTRIFUGE TESTING**

Richard E Holdeman / In AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 15 p. refs. (For availability see N74-14345 05-21)

The development and characteristics of a centrifuge for testing inertial guidance systems are discussed. The subjects presented are (1) overall centrifuge capability, (2) test methods and sequence for testing a typical system, (3) instrumentation to monitor all signals for on-line data validation, (4) methods for computer data processing, and (5) test philosophy for evaluating component performance at the system level. Author

N74-14349 Dornier-System G.m.b.H., Friedrichshafen (West Germany)

**TESTING OF AN ATTITUDE CONTROL UNIT FOR SOUNDING ROCKETS**

Hartmut S.emann / In AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 8 p. (For availability see N74-14345 05-21)

After a general view of the structure of an attitude control unit for sounding rockets a short description of the equipment available for the test of attitude control systems is given. On this basis a test philosophy is shown which allows a thorough testing of the attitude control unit at optimal costs. This can be done by a test program which examines every phase of the attitude control maneuver completely but without redundancy. Within this scope also environmental test, is dealt with. In the following some practical guidelines for preparation and execution of the tests are given, whereby the engagement of the customer plays a significant role. Author

N74-14350 Central Inertial Guidance Test Facility, Holloman AFB, N.Mex.

**LABORATORY EVALUATION OF ELECTRO-OPTICALLY AIDED SPACE NAVIGATION SYSTEMS**

Walter G Peterson / In AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 10 p. refs. (For availability see N74-14345 05-21)

A key step in any development program is the laboratory testing which provides a means of demonstrating the design concept and hardware performance. The success of this testing is dependent upon both laboratory accuracy and the faithfulness with which the systems' operational environment is duplicated within the laboratory. The greatly increased accuracy and complexity of electro-optically aided space navigation systems that are currently being developed, force the test engineer to devise new test methods in order to insure the validity of his results. This paper seeks to explain the approach that the Central Inertial Guidance Test Facility (CIGTF) is pursuing to meet this challenge. It discusses the way past systems have been tested and the methodology which will be used to evaluate future ones. Author

N74-14351 Elektronik-System G.m.b.H., Munich (West Germany)

**TRENDS TOWARDS STANDARDIZED SOFTWARE AND HARDWARE FOR TEST SYSTEMS**

B. Eichenauer, M. Mall, and G. Schweizer (Dornier-System G.m.b.H.) / In AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 20 p. refs. (For availability see N74-14345 05-21)

The use of automatic test equipment for check-out of aircraft before flight is discussed. A check-out system comprises an equipment to stimulate the system to be tested with defined test signals, measuring units, the interconnection system for the connection of all parts with the required test signals and measuring units, the process computer with the interface unit and input/output peripherals. There is a requirement for a variety of different stimuli and measuring units. Examples are ac and dc test signal sources, hydraulic transducers, mechanical transducers, instruments measuring current, voltage, power, pressure, rotations. The required software is as important for the operation of a check out system as the hardware itself. The test procedures for the specific

system to be tested, the specification for the stimuli and the measuring units to be applied and the basic software for the computer and the process peripherals as well as the user program for the specific check-out equipment and the system to be tested are all parts of the software complex. Author

**N74-14352** Royal Aircraft Establishment, Farnborough (England)

#### **AIRCRAFT INERTIAL SYSTEM TESTING AND EVALUATION IN THE UNITED KINGDOM**

R. F. Stokes and S. G. Smith. *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 49 p (For availability see N74-14345 05-21)

Internal system testing by Government Departments in the United Kingdom is undertaken by two Establishments - RAE Farnborough and A and AEE Boscombe Down. For historical reasons most flying is done at A and AEE where a fully instrumented aircraft has been provided for precise navigation trials but the methods used are largely derived at RAE. Details of the reference equipment available, its advantages and drawbacks, are given together with a description of the methods used to obtain a high quality, world-wide position and velocity reference. Various methods of obtaining statistical performance parameters are discussed and their consistency is demonstrated. The problems of performance diagnosis are illustrated with a worked example which also shows the use of a digital mathematical model of an IN system. Some ideas on a possible new approach to inertial system testing are also given. Author

**N74-14353** Central Inertial Guidance Test Facility, Holloman AFB, NMex

#### **AIRCRAFT NAVIGATION SYSTEMS TESTING WITH A HIGH PRECISION REFERENCE**

Melvin Birnbaum. *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 11 p refs (For availability see N74-14345 05-21)

The development and characteristics of an aircraft test bed and a Completely Integrated Reference Instrumentation System (CIRIS) are described. The system uses a display system with alphanumeric and graphic representation to provide indications of system operation. The components of the system are illustrated and procedures for conducting the tests are analyzed. Author

**N74-14354** Central Inertial Guidance Test Facility, Holloman AFB, NMex

#### **INERTIAL GUIDANCE SYSTEM SLED TESTING**

G. R. Mozer. *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 31 p refs (For availability see N74-14345 05-21)

The techniques used for precision sled testing of inertial and terminal guidance systems and components under high sustained linear accelerations with superimposed vibration on the Holloman fifty thousand foot high speed rocket sled test track are discussed. This track is instrumented with a precision position and time measuring system which measures the sled velocity to better than 0.02 feet/second. Sledborne magnetic tape recorders and radio frequency (RF) telemetry are used to obtain data. Time digitization of guidance system data for automatic computer processing is utilized. Strapped-down and gimbaled systems have been tested. Accelerometers are tested in system configuration by installing them on a modified inertial platform. Static calibration of accelerometer bias and scale factor, gyro drift coefficients, and inertial component non-orthogonality measurements are made between sled runs. Accelerometer error models include terms which are a function of steady state acceleration inputs and dynamic acceleration sensitive terms. Propagation of individual error sources as a function of acceleration profile is examined. Author

**N74-14355** Thomson-CSF, Bagneux (France)

#### **ROLE OF SIMULATIONS IN THE STUDY AND DEVELOPMENT OF THE CROTALE SYSTEM**

G. Paretti. *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 21 p. In FRENCH and ENGLISH (For availability see N74-14345 05-21)

After a general description of the CROTALE Weapon System, the main stages of the technical program development are indicated. Then the role of simulations is discussed in further detail and the methodology of their use, on several levels, is stressed. Attention is drawn to the basic character of a constant adjustment of simulations to experimental results. Finally, an application of methodology is illustrated by a practical example, and simulation results are compared to test results. Author

**N74-14356** Central Inertial Guidance Test Facility, Holloman AFB, NMex

#### **TERMINAL GUIDANCE SYSTEM TESTING**

Felix E. Morgan. *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 21 p ref (For availability see N74-14345 05-21)

Through the proper combination of complementary non-destructive tests and verification by a limited number of live firings, it is now possible to increase the test cost effectiveness (test validity divided by test cost) for terminally guided weapon systems. These non-destructive tests are conducted under an 'integrated test' concept. This concept dictates complementary tests in varied test arenas, each providing some benefit not available in the others. The results of all these non-destructive tests are then incorporated into a guidance performance propagation computer program to arrive at 'guidance only' total system performance. The validity of the performance propagation for the particular system under test may then be verified by a limited number of live launches. These valid guidance performance indicators can then be combined with non-guidance performance data to predict total weapon system effectiveness over a wider realm of launch parameters. This can also be done at a lower cost than would have been possible utilizing only a large number of live launches. The Guidance Test Division at Holloman AFB, New Mexico, is conducting such integrated tests. This paper presents the detailed descriptions of the test facilities, test methods, and data reduction techniques required to arrive at the performance indicators inputs to the guidance performance propagation computer program. Author

## 22 NUCLEAR ENGINEERING

Includes nuclear reactors and nuclear heat sources used for propulsion and auxiliary power. For basic research see 24 Physics, Atomic, Molecular, and Nuclear. For related information see also 03 Auxiliary Systems, and 28 Propulsion Systems.

No abstracts in this subject category



## 23 PHYSICS, GENERAL

Includes acoustics, cryogenics, mechanics, and optics. For astrophysics see 30 Space Sciences. For geophysics and related information see also 13 Geophysics, 20 Meteorology, and 29 Space Radiation

**N73-33619#** Advisory Group for Aerospace Research and Development, Paris (France)

### OPTICS OF THE SEA (INTERFACE AND IN-WATER TRANSMISSION AND IMAGING)

Aug 1973 431 p. In ENGLISH, partly in FRENCH (AGARD-LS-61) Avail NTIS HC \$23 75

The proceedings of a conference on the optical properties of the sea are reported. The subjects discussed include the following: (1) reflection and refraction of light at the sea surface, (2) refractive index fluctuations in sea water, (3) the theory of small angle scattering, (4) underwater visibility and imaging, (5) sources of light for underwater illumination, (6) long range vision techniques, and (7) spatial filtering and image restoration. For individual titles, see N73-33620 through N73-33638

**N73-33620** Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France) Div des Previsions Ionospheriques

### INTRODUCTION TO THE ELECTROMAGNETISM OF THE SEA [INTRODUCTION A L'ELECTROMAGNETISME DES MERS]

P. Halley. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 38 p. refs. In FRENCH (For availability see N73-33619 24-23)

The Debye theory of polarization of liquids was used to calculate real permittivity and conductivity of the sea. Also, visible light temperature measurements were used to observe superficial temperature and chemical composition of the sea surface. The effects of surface emissivity, reflection, and refraction are discussed. Transl. by E.H.W.

**N73-33621** Institute of Physical Oceanography, Copenhagen (Denmark)

### RADIANCE DISTRIBUTION BELOW THE SEA SURFACE

Kjell Nigard. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 22 p. refs. (For availability see N73-33619 24-23)

Radiance distribution as a function of depth are the most basic radiometric quantities for describing the structure of the solar and global field of radiation in the upper layers of the sea. Immediately below the sea surface the radiance distribution is chiefly determined by the radiance distribution above the surface and by the reflecting and refracting properties of the air-sea interface. Through the processes of absorption and scattering by the water itself and by dissolved and suspended matter the initial radiance distribution is progressively changed with increasing depth. A survey is given of concepts of inherent and apparent optical properties, and simple models describing their interrelations and relations to the radiance distribution through the classical time-independent equation of radiative transfer are presented. Some experimental data are presented and discussed. A brief account of the polarization of the underwater light field is given. Author

**N73-33622** Centre de Recherches Oceanographiques, Villefranche-sur-Mer (France) Lab d'Oceanographie Physique

### BRIEF ON THE THEORIES OF RADIATIVE TRANSFER: APPLICATION TO PROPAGATION IN THE SEA [APERCU SUR LES THEORIES DU TRANSFERT RADIATIF APPLIQUES A LA PROPAGATION DANS LA MER]

L. Prieur and A. Morel. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 25 p. refs. In FRENCH (For availability see N73-33619 24-23)

Several theories on the propagation of electromagnetic waves

in sea water, are briefly discussed. Data cover transfer equations, computer methods, spherical harmonics, asymptotic methods, and perturbation theory. Transl. by E.H.W.

**N73-33623** Paris Univ (France) Lab d'Oceanographie Physique

### SOLAR ENERGY AND SEASONAL THERMOCLINE [ENERGIE SOLAIRE ET THERMOCLINE SAISONNIERE]

J. P. Bethoux and A. Ivanoff. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 7 p. refs. In FRENCH (For availability see N73-33619 24-23)

Various factors affecting the seasonal thermocline of the sea are studied by marine photometry. Specifically, the effects of advection, vertical temperature profiles, energy absorption, mixing boundary layer, and marine currents are discussed. Transl. by E.H.W.

**N73-33624** Paris Univ (France) Lab d'Oceanographie Physique

### PHYSICAL FACTORS, CHEMICAL AND BIOLOGICAL EFFECT OF THE PROPAGATION OF LIGHT IN SEA WATER

Alexandre Ivanoff. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 45 p. refs. In FRENCH (For availability see N73-33619 24-23)

Definitions are given of parameters pertinent to characterizing the optical properties of turbulent and pure sea water. Various other factors affecting the optical properties of sea water including materials suspended in the water, substances in solution, and incidence of refraction are discussed. Data are also given on the spatial and temporal distribution of optical properties. Transl. by E.H.W.

**N73-33625** Tetra Tech Inc, Pasadena, Calif

### REFRACTIVE INDEX FLUCTUATIONS IN SEA WATER

Henri Modara. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 14 p. refs. (For availability see N73-33619 24-23)

Mathematical methods for predicting the effects of thermal and saline inhomogeneities on optical imaging systems are presented. Temperature and salinity variations cause corresponding fluctuations in the refractive index resulting in loss of resolution. Formulas are developed for the refractive index changes in terms of their gradient with respect to salinity and temperature. It is stated that a dual-scan system is fairly immune to temperature and salinity fluctuations. Author

**N73-33626** Oregon State Univ, Corvallis School of Oceanography

### VARIATION OF OPTICAL SEA PARAMETERS WITH DEPTH

J. Ronald V. Zanevald. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 22 p. refs. (For availability see N73-33619 24-23)

The depth dependence of light scattering and attenuation parameters in the ocean are discussed. The theoretical dependence of optical parameters on the concentration, size distribution and physical parameters of the particulate matter is discussed. A simple model for the depth dependence of particulate matter concentrations is presented. Results agree qualitatively with observed distributions. The interrelation of optical parameters, particle concentration, and hydrographic parameters as obtained from experimental observations in several areas is discussed. Author

**N73-33627** Centre de Recherches Oceanographiques, Villefranche-sur-Mer (France)

### DIFFUSION OF LIGHT BY SEA WATER: EXPERIMENTAL RESULTS AND THEORETICAL APPROACH [DIFFUSION DE LA LUMIERE PAR LES EAUX DE MER: RESULTATS EXPERIMENTAUX ET APPROCHE THEORIQUE]

Andre Morel. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 73 p. refs. In FRENCH (For availability see N73-33619 24-23)

Several theories - Rayleigh, Rayleigh-Gans and Mie used to calculate light propagation in sea water as a function of

absorption and diffusion are discussed. The effects of polarization, polydispersed and spherical particles, and long wave radiation are also discussed. Definitions of various parameters used and experimental results are given in an appendix. Transl. by E.H.W.

**N73-33628** Tetra Tech, Inc., Pasadena, Calif.  
**THEORY OF SMALL ANGLE SCATTERING**

Willard H. Wells. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 19 p. refs. (For availability see N73-33619 24-23)

The fundamental description of light scattering by particles in sea water is presented. The volume scattering function is defined as the amount of light scattered per meter into a differential solid angle in a given direction. For multiple scattering a derived quantity called the point spread function is needed to describe the intensity blur distribution at a given range. Numerical relationships are developed to show the effects of various parameters on visibility conditions. Author

**N73-33629** Tetra Tech, Inc., Pasadena, Calif.  
**EXPERIMENTAL RESULTS OF SMALL ANGLE SCATTERING**

Henri Hodara. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 17 p. refs. (For availability see N73-33619 24-23)

The characteristics of light scattering at large angles, small angles, and very small angles. For each of the angular ranges, the relative contributions from refraction and diffraction are calculated. It was determined that large angle scattering is mostly due to diffraction, while refraction is responsible at small angles. The results of scattering measurements by point spread function and by modulation transfer function are presented. Author

**N73-33630** Tetra Tech, Inc., Pasadena, Calif.  
**FACTORS AFFECTING LONG RANGE VISION**

Willard H. Wells. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 10 p. refs. (For availability see N73-33619 24-23)

The various phenomena which affect long range underwater vision are discussed. The most important factors are: (1) decay of light in narrow and broad beams; (2) light backscattered from particulate matter; (3) return light whose image information is scrambled by small angle scatter enroute to the detector; (4) the statistics of detected photons; and (5) signal to noise ratio criteria for imaging. Mathematical models are presented to show the effects of the various factors. Author

**N73-33631** Tetra Tech, Inc., Pasadena, Calif.  
**CRITERIA FOR VISION: RESOLUTION, SIGNAL TO-NOISE RATIO CONTRAST**

Henri Hodara. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 13 p. refs. (For availability see N73-33619 24-23)

The vision criteria of resolution, signal to noise ratio, and contrast are discussed. The concepts are applied to calculate the ultimate resolution of underwater imaging systems. It is stated that a signal to noise ratio of five is sufficient to ensure image quality. Mathematical models of the factors affecting underwater vision are developed. Author

**N73-33632** Tetra Tech, Inc., Pasadena, Calif.  
**MEDIUM AND SYSTEM TRANSFORM FUNCTIONS**

Willard H. Wells. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 16 p. (For availability see N73-33619 24-23)

The application of Fourier techniques to calculate the spread of scattered light surrounding other distributions is discussed for cases of a circular spot, a beam with Gaussian profile, and a linear stripe. The quantities needed for round trip propagation from transmitter to receiver are defined. A formula for particle backscattering is developed. A table of blur and offset distributions and the related Fourier transforms and transfer functions is included. Author

**N73-33633** Tetra Tech, Inc., Pasadena, Calif.  
**SOURCES: ARC, FLASH, INCANDESCENT AND LASER LAMPS**

Henri Hodara and Willard H. Wells. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 17 p. refs. (For availability see N73-33619 24-23)

The major classes of incoherent and coherent sources of light for underwater applications are discussed. A performance comparison figure for lamps is developed based on the square root of the round trip light attenuation from lamp to camera taking into account the source, the medium, and the receiver spectral sensitivity. It is stated that the selection of a lamp is dictated by efficiency. In that respect, incoherent sources are superior to lasers for most underwater illumination applications. Author

**N73-33634** Tetra Tech, Inc., Pasadena, Calif.  
**RECEIVERS: PHOTOELECTRIC AND PHOTOGRAPHIC DETECTORS**

Henri Hodara and Willard H. Wells. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 15 p. (For availability see N73-33619 24-23)

A procedure for comparing photo-electronic and photographic detectors is discussed. The criterion is based on the product of the signal to noise ratio and the spatial bandwidth. The subjects discussed are: (1) fundamentals for comparing detector performance; (2) units for measuring resolution; (3) characteristics of photoelectronic image detectors; and (4) characteristics of photographic film used with photoelectronic equipment. Author

**N73-33635** RCA Service Co., Inc., Patrick AFB, Fla.  
**UNDERWATER LENSES AND OPTICAL PORTS**

Lawrence F. Martens. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 25 p. refs. (For availability see N73-33619 24-23)

Basic theoretical and practical aspects of using lenses and ports in underwater imaging systems are reviewed. Terminology is defined and formulas for estimating field of view, distortion and other aberrations are presented. Several types of optical systems for correcting aberrations are reviewed. The depth of field and relative aperture are compared for several lens port combinations. Applications of short focal length, long focal length, and supplementary lenses are reviewed. Author

**N73-33636** Tetra Tech, Inc., Pasadena, Calif.  
**LONG RANGE VISION TECHNIQUES**

Willard H. Wells. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 13 p. refs. (For availability see N73-33619 24-23)

Techniques for long range vision are discussed. Two methods, range gating and dual scan with parallax, are described. The treatment assumes unsaturated photoelectronic detectors that are limited by photon noise not contrast. A range gated system with radar like pulses offers the ultimate solution for long range vision as far as eight attenuation lengths and beyond with badly degraded resolution. The best alternative to range gating is a dual scan system in which the illuminator and receiver are separated for parallax. The practical limit is about seven attenuation lengths unless range gating is added to eliminate luminance in nearby water. Author

**N73-33637** Tetra Tech, Inc., Pasadena, Calif.  
**SPATIAL FILTERING AND IMAGE RESTORATION**

Henri Hodara. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging). Aug. 1973. 12 p. (For availability see N73-33619 24-23)

The exponential dependence of the ocean transfer function on range and the application to image restoration are discussed. An inverse filter to restore photographs of flooded targets blurred by turbulence is described and the limitations are analyzed. The resolution degradation caused by a mismatch between filter and medium transfer functions is calculated. The signal to noise ratio required to achieve various restorations is analyzed. Author

N73-33638 Terra Tech, inc., Pasadena, Calif

**FORTRAN ALGORITHMS FOR UNDERWATER OPTICS**

Willard H. Wells. In AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 17 p (For availability see N73-33619 24-23)

The application of FORTRAN algorithms for underwater optics is discussed. The functions performed by various subroutines are described. An example of a complete computer program is provided. The selected program has utility for fundamental studies of water properties. It accepts a number of point spread functions measured at different distances and computes the spatial frequency decay function from each of them. Author

**24 PHYSICS, ATOMIC, MOLECULAR,  
AND NUCLEAR**

Includes atomic, molecular and nuclear physics. For applications see 22 Nuclear Engineering. For related information see also 29 Space Radiation.

No abstracts in this subject category

25 PHYSICS, PLASMA

Preceding page blank

247

## 25 PHYSICS, PLASMA

Includes magnetohydrodynamics For applications see 28  
Propulsion Systems

No abstracts in this subject category

**26 PHYSICS, SOLID-STATE**

Includes semiconductor theory, and superconductivity. For applications see 16 Metals. For related information see also 10 Electronics.

No abstracts in this subject category

## 27 PROPELLANTS

Includes fuels, igniters, and oxidizers. For basic research see 08 Chemistry, and 33 Thermodynamics and Combustion. For related information see also 28 Propulsion Systems.

**N72-11666#** Advisory Group for Aerospace Research and Development, Paris (France).

**AIRCRAFT FUELS, LUBRICANTS, AND FIRE SAFETY**

Aug 1971 401 p refs Presented at 37th Meeting of the AGARD Propulsion and Energetics Panel, The Hague, 10-14 May 1971

(AGARD-CP-84-71) Avail NTIS HC \$6.00/MF \$0.95

Papers are presented on aircraft fuels, their production, analysis, and testing. Fuel handling, fuel and fire safety, and lubricants are also discussed, using impact tests and crash simulations. For individual titles, see N72-11666 through N72-11701

**N72-11669#** National Research Council of Canada, Ottawa (Ontario). Fuels and Lubricants Lab

**JET FUEL SPECIFICATIONS**

L Gardner and R B Whyte. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs (See N72-11668 02-27)

Avail NTIS HC \$6.00/MF \$0.95

Various military and civil jet fuel specifications are compared and their differences noted, particularly with reference to different types of additives which are used on a mandatory or optional basis. Specification test procedures and their importance in relation to limits are discussed and the increased complexity of quality control for jet fuel specifications is noted. Author

**N72-11670#** France Service Technique de l'Aeronautique, Paris

**AERONAUTICAL SIGNIFICANCE OF POLYCYCLIC SATURATED HYDROCARBONS [INTERET AERONAUTIQUE DES HYDROCARBURES POLYCYCLIQUES SATURES]**

G Verdic. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs In FRENCH (See N72-11668 02-27)

Avail NTIS HC \$6.00/MF \$0.95

The range of an airplane depends on the amount of energy used. When reservoir capacity is too limited, it is possible to extend the range by using a higher energy fuel. In this sense, high energy polycyclic saturated hydrocarbons are possible fuels for supersonic aerodynamics in the near future, especially since their thermal stability is superior to that of present fuels. Essential fuel characteristics are presented together with the results of experimentation. Industrial fabrication problems and future perspectives are considered. Transl. by K P D

**N72-11671#** Shell Research, Ltd., Chester (England). Thornton Research Centre

**FUELS FOR SUPERSONIC AND HYPERSONIC AIRCRAFT**

A Lewis, H Strawson, and J G Kintley. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs Sponsored in part by Min. of Aviation Supply (See N72-11668 02-27)

Avail NTIS HC \$6.00/MF \$0.95

The first generation of supersonic aircraft is being designed to operate on existing kerosene-type fuels. The limitations of these fuels are reviewed and possibilities considered for propellants for higher-speed aircraft, serving the triple purpose of cooling the airframe, cooling engine components, and providing propulsive energy. Problems of vapor deposition in hot fuel systems are covered and the possibilities explored of increasing the cold-sink value of the fuel by precooling or by endothermic decomposition. The calorific values of different fuels and the importance of recombination of dissociated combustion products is stressed. Ways of speeding such recombination are indicated. Author

**N72-11672#** Shell Development Co., Emeryville, Calif.  
**COOLING OF ADVANCED ENGINES BY ENDOTHERMIC REACTIONS OF HYDROCARBON FUELS**

L E. Faith, G H Ackerman, and M T Henderson. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 8 p refs Sponsored by AFAPL (See N72-11668 02-27)

Avail NTIS HC \$6.00/MF \$0.95

The fuel used in an engine is a convenient coolant, absorbing heat as sensible heat and latent heat of vaporization. Certain hydrocarbon fuels can furnish additional heat sink in the form of endothermic reactions. Possible endothermic reactions include thermal reactions such as cracking, and catalytic reactions such as dehydrogenation, dehydrocyclization, and depolymerization. Of these, the catalytic dehydrogenation of naphthalene to aromatics is the most promising type of reaction. For example, the dehydrogenation of methylcyclohexane over platinum/alumina catalyst furnishes a reaction heat sink of approximately 1000 Btu/lb fuel, which is slightly greater than the cooling capacity due solely to sensible heat and latent heat of vaporization. This reaction is very selective and proceeds rapidly to achieve high conversion of methylcyclohexane to toluene and hydrogen. The total heat sink for such a reaction system compares favorably with that of hydrogen when these heat sinks are normalized by the heat of combustion of the fuel. Author

**N72-11673#** Monsanto Research Corp., Dayton, Ohio  
**APPLICATION OF ANALYTICAL TECHNIQUES FOR THE ANALYSIS OF ADDITIVES AND CONTAMINANTS IN ADVANCED HYDROCARBON FUELS**

W G Scribner. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 7 p refs (See N72-11668 02-27) (Contract F33616-69-C-1326)

Avail NTIS HC \$6.00/MF \$0.95

A rapid method based on a specific ion electrode technique was adapted and verified for the determination of micrograms/g quantities in fuel of a fluorine-containing additive. A measurement method for ng/g levels of lead in hydrocarbon fuels is described, and the noninterference of allowed fuel additives is demonstrated. Examples are also cited where polar compound contaminants at the microgram/g level were isolated and identified by a combination of column chromatography and infrared spectrophotometry. Various factors which must be considered in method adaptation are reviewed, and the need for close communication between the fuel handling engineer and the analyst to expedite the solution of fuel contamination problems is stressed. Author

**N72-11674#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Munich (West Germany). Inst fuer Flugtrieb- und Schmierstoffe

**THE POSSIBILITIES OF ACTUALLY TESTING THE COMBUSTION CHARACTERISTICS OF AVIATION FUELS WITH APPROPRIATE EQUIPMENT**

H Gempeler. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs (See N72-11668 02-27)

Avail NTIS HC \$6.00/MF \$0.95

Small-scale combustion chamber rigs are described, with which combustion characteristics of aviation fuels are being tested. The relationship of the chemical constitution of the fuels and their chemical-physical properties, and the processes during preparation and combustion of fuel is determined. Investigation is conducted at different air and fuel temperatures and at different high pressures in the combustion chamber in a parallel flow. Temporally consecutive processes during fuel preparation and combustion may also be specially separated and thereby provide for a measurement with customary probes as well as spectroscopic methods. Author

**N72-11675#** Pisa Univ (Italy). Lab Prove Combustibili  
**LOW EMISSION FUELS AND DEVICES FOR AVIATION ENGINES**

G Nardi. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 13 p refs (See N72-11668 02-27)

Avail NTIS HC \$6.00/MF \$0.95

Reduction of harmful emissions of turbine engine exhaust system is reviewed. The type of fuel used, combustion chambers, and operating conditions of combustors are also investigated. Author

**N72-11676#** National Research Council of Canada, Ottawa (Ontario) Fuels and Lubricants Lab  
**FUEL CLEANLINESS**

L. Gardner. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971. 13 p refs (See N72-11688 02-27)  
Avail NTIS HC \$6 00 MF \$0 95

Dual purpose filter/separators were developed which could remove both dirt and water. Improvements in the performance of filter/separators was achieved by compliance with increasingly severe specifications. Methods of determining undissolved water and dirt in fuel and their development both for filter/separator testing and field use are discussed. Fuel contamination by microorganisms and surfactants has led to serious cases of aircraft corrosion and filter plugging. Measures to control or eliminate these two contaminants are discussed. Author

**N72-11677#** Lucas Gas Turbine Equipment, Ltd., Burnley (England)

**FUEL RELATED PROBLEMS IN AIRCRAFT FUEL SYSTEMS**  
S. L. Forgham and R. G. Beckett. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971. 14 p refs (See N72-11688 02-27)

Avail NTIS HC \$6 00 MF \$0 95

Aircraft fuel problems are discussed, emphasizing problems associated with hydrogen treated fuels. Some of the problems were overcome by fuel system design modification, and other changes are reviewed which were instituted by refinery industries. Research on fuel sealing is also described. J. A. M.

**N72-11678#** BP Trading Ltd., London (England)

**AIRCRAFT FUELLING OPERATIONS AND QUALITY CONTROL**

G. R. Parker. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971. 12 p refs (See N72-11688 02-27)  
Avail NTIS HC \$6 00 MF \$0 95

Aviation fuelling facilities and the fuelling operation are described. Comments on the types of aircraft are restricted to those aspects directly affecting fuelling. Author

**N72-11679#** Esso Development Co., Ltd., Abingdon (England) Research Centre

**AVIATION FUEL LUBRICITY**

R. A. Vere. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971. 13 p refs (See N72-11688 02-27)  
Avail NTIS HC \$6 00 MF \$0 95

A laboratory test rig was developed to evaluate European jet fuels with regard to lubricity. This has shown differences in the lubricity levels of different fuels. Active lubricity agents were identified as fully saturated heterocyclic compounds and polynuclear aromatics. The addition of a surface active additive such as a corrosion inhibitor also significantly improve lubricity but can incur conductivity problems in the field due to its synergistic effects with antistatic additive. The feasibility of a fuel lubricity test by chemical, physical or mechanical techniques are being studied. Author

**N72-11680#** Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.

**FLAME INHIBITION CHEMISTRY**

R. M. Fristrom and R. F. Sawyer. In AGARD Aircraft Fuels, Lubricants, and Fire Safety refs (See N72-11688 02-27)  
(Grant NSF G1-12)

Avail NTIS HC \$6 00 MF \$0 95

Techniques involving diverse mechanisms are employed in extinguishing flames and fires. Mechanisms were divided into two broad categories: (1) physical mechanisms when mechanical or thermal effects are dominant and (2) chemical mechanisms when chemical effects are involved. Flame extinguishment viewed from the standpoint of the effects on the elementary reaction processes is reviewed. A simplified hydrogen-oxygen flame chemistry is used as an illustration. The complications introduced by chemical inhibition are pointed out. The chemical kinetic information in the area of hydrogen atom scavenging and oxygen flame radical recombination is surveyed. Author

**N72-11681#** Air Force Systems Command, Wright-Patterson AFB, Ohio Aero Propulsion Lab

**FLAMMABILITY PROPERTIES OF JET FUELS AND TECHNIQUES FOR FIRE AND EXPLOSION SUPPRESSION**

B. P. Botten. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971. 11 p refs (See N72-11688 02-27)

Avail NTIS HC \$6 00 MF \$0 95

Results of investigative efforts to establish the practical flammability envelopes and associated combustion damage potential for conventional jet fuels such as JP-4, JP-6 (similar to JET A-1), and JP-8 under simulated hostile operating environment conditions are presented. Testing included liquid-space gunfire hits to assess external fire hazard and vertical (liquid to vapor) firing trajectories to determine explosion hazard associated with projectile-induced fuel sprays and mists. All tests were performed in instrumented replica target tanks varying in volume from 16 to 90 gallons. Principal test variables were fuel temperature, pressure, fuel depth, external void space, and internal and external air flow. All tests were conducted utilizing 0.50-caliber armor piercing incendiary projectiles. These tests indicate a considerable extension in the flammability range of all fuels compared to the equilibrium flammability limit values which are commonly utilized for fire safety analysis. In view of the fire and explosion potential exhibited by all conventional jet fuels, additional measures must be employed to achieve an effective fire-protection capability. Progress in the use of reticulated polyurethane foam, halogenated hydrocarbon chemical extinguishers, and other fuel-tank-venting techniques is also reviewed. Author

**N72-11682#** Institut Francais du Pétrole, Paris (France)

**INFLUENCE OF MOLECULAR STRUCTURE ON SELF-IGNITION PROPERTIES OF HYDROCARBONS [INFLUENCE DE LA STRUCTURE MOLECULAIRE SUR CERTAINES PROPRIETES D'AUTO-INFLAMMATION DES HYDROCARBURES]**

G. DeSoete. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971. 12 p refs. In FRENCH, ENGLISH summary (See N72-11688 02-27)

Avail NTIS HC \$6 00 MF \$0 95

The adiabatic compression method was used to determine delays in self-ignition by different hydrocarbon-air mixtures as a function of pressure and temperature. A comparison of experimental results makes it possible to evaluate the effect of some special molecular structure characteristics on the overall activation energy. In particular, the presence of tertiary carbon atoms and double carbon-carbon bonds results in a decrease in this activation energy. Tests made with mixtures of two different hydrocarbons show that the kinetic parameters controlling the dependency of ignition delay on temperature vary in such a way that the delay with a mixture tends to approach that of the pure component having the shortest delay at the temperature considered. This phenomenon was found to be all the greater as the relative concentration of this component in the binary mixture is higher. Author

**N72-11683#** Princeton Univ., NJ Guggenheim Lab

**IGNITION OF FUELS BY A HOT PROJECTILE**

O. P. Sharma and W. A. Sirignano. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971. 16 p refs (See N72-11688 02-27)

Avail NTIS HC \$6 00 MF \$0 95

Theoretical investigations were performed by approximating (1) the flow at the forward end of the projectile to a stagnation flow towards a hot axisymmetric body, (2) the flow over its surface to a laminar flow over a hot plate, and (3) the flow in the wake of the projectile to a plane laminar mixing of the cold unreacted mixture with the hot combustion products. After the premixed mixture is exhausted there is a possibility of ignition of unmixed reactants by the hot inert products which are left behind and are sandwiched between the oxidizer and the fuel. A theoretical analysis for the ignition delay time as a function of the temperature and the width of the hot gas region is also presented. Author



N72-11684# Centre National de la Recherche Scientifique Paris (France)

**INFLUENCE OF PROMOTERS (FREE RADICALS) AND INHIBITORS ON DIFFUSION FLAMES [INFLUENCE DES PROMOTEURS (RADICAUX LIBRES) ET DES INHIBITEURS SUR LES FLAMMES DE DIFFUSION]**

J. Combourieu, C. Felinower, and G. Denis. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs. In FRENCH, ENGLISH summary (See N72-11668 02-27)

Avail. NTIS HC \$6.00/MF \$0.95

The laminar diffusion flames of acetylene with molecular oxygen and with molecular oxygen partly dissociated were stabilized in a low pressure vessel. A partial dissociation of O<sub>2</sub> into O atoms was produced by a powerful microwave discharge. Concentration profiles of stable species were determined with a microprobe and a mass spectrometer. Temperature profiles were obtained from a silica-coated thermocouple. The intensities of spectral emission were recorded for excited species with a spectrophotometer. The complex structure of these diffusion flames shows that the combustion of C<sub>2</sub>H<sub>2</sub> involves several steps. The partial dissociation of O<sub>2</sub> emphasizes the significant role played by O atoms in the combustion of C<sub>2</sub>H<sub>2</sub>. The influence of halogenated inhibitors is very different according to the kind of inhibitor and whether it is added to the oxidizer or the fuel.

Author

N72-11685# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst fuer Luftstrahltriebwerke

**CONTRIBUTION TO THE SELECTION OF FIRE EXTINGUISHING SYSTEMS AND AGENTS FOR AIRCRAFT FIRES**

R. Fiele. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 10 p refs. (See N72-11668 02-27)

Avail. NTIS HC \$6.00/MF \$0.95

A fire extinguishing system in aircraft is described which uses the exhaust gases of a solid propellant gas generator to pressurize the extinguisher bottle. The extinguishing efficiency of this hot-bottle system is compared with that of the current extinguishing system. The amount of agent which is necessary to extinguish a diffusion flame was measured for a number of halons, dry powders, and mixtures of dry powders and halons. The ability of agents to prevent reignition of the extinguished fuel surface by hot parts was also tested.

Author

N72-11686# Shell Research Ltd., Chester (England)

**ELECTROSTATIC CHARGING IN THE HANDLING OF AVIATION FUELS**

M. Strawn and A. Lewis. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs. (See N72-11668 02-27)

Avail. NTIS HC \$6.00/MF \$0.95

Electrostatic charging of the fuel during fueling can result in the possibility of incendiary sparking in aircraft tanks, some of the more recent experimental results on the different phases of this process are presented. These results confirm that in the absence of special precautions, discharges creating a tank explosion hazard can exist during aircraft refueling in certain circumstances. Unless the fuel conductivity is controlled, however, these hazardous circumstances cannot be precisely predicted. The use of a static dissipator additive eliminates the hazard. Methods of introducing the additive and of maintaining the correct conductivity during fuel distribution are discussed, as well as possible side effects and interactions with other fuel additives. On the basis of world-wide airline use over many years supported by many laboratory tests, it is concluded that the additive provides a safe, simple and trouble-free solution to the problem.

Author

N72-11687# National Aviation Facilities Experimental Center Atlantic City, NJ

**CRASH SAFE TURBINE FUEL DEVELOPMENT BY THE FEDERAL AVIATION ADMINISTRATION, 1964 - 1970**

R. A. Russel, Jr. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 10 p refs. (See N72-11668 02-27)

Avail. NTIS HC \$6.00/MF \$0.95

Crash-safe fuel program, a segment of a primary mission to improve the overall crashworthiness of aircraft, is discussed. The reduction of the probability and severity of fire during aircraft ground crash situations is also examined.

Author

N72-11688# Southwest Research Inst., San Antonio, Tex. Army Fuels and Lubricants Research Lab

**EMULSIFIED FUELS AND AIRCRAFT SAFETY**

W. D. Weatherford, Jr. and F. W. Schaeckel (Army Coating and Chem Lab). In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs. (See N72-11668 02-27)

(Contracts DAAD05-70-C-0260, DAAJ02-69-C-0030)

Avail. NTIS HC \$6.00/MF \$0.95

Research and development program aimed at improving the post-crash fire safety of helicopter turbine-engine fuels is reviewed. Primary emphasis was placed on high-internal-phase-ratio aqueous emulsions. Interrelations among rheological and physical properties, composition, and fire safety characteristics of various fuel formulations are discussed. Implications of these results on the total safety envelope of rotary wing aircraft are examined.

Author

N72-11689# Bureau of Mines, Pittsburgh, Pa. Mining and Safety Research Center

**FIRE HAZARD EVALUATION OF THICKENED AIRCRAFT FUELS**

J. M. Kuchta, J. N. Murphy, A. L. Furno, and A. Bartkowiak. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs. (See N72-11668 02-27)

Avail. NTIS HC \$6.00/MF \$0.95

Various gelled or emulsified fuels were proposed for reducing the aircraft crash-fire hazard. Results are presented from bench-scale tests for screening the fuels and from large-scale drop tests for evaluating their fire hazard under simulated crash conditions. Jet A and Jet B type thickened fuels were investigated. Their minimum autoignition temperatures and burning rates varied little, whereas their flash points, volatility rates, self-spread rates, and flame spread rates varied noticeably with either the base fuel or thickening agent composition. Minimum ignition energies are also compared for liquid sprays. The performance of the thickened fuels, particularly Jet B emulsions, was not very promising under impact conditions. In fuel drops made from a 150-ft three-tower facility, the fireball size and radiation intensity varied with impact velocity, impact angle, and type of fuel container.

Author

N72-11690# Royal Aircraft Establishment, Farnborough (England) Engineering Physics Dept.

**FIRE AND EXPLOSION PROTECTION OF FL TANK ULLAGE**

J. A. MacDonald and H. W. G. Wyeth. In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 7 p refs. (See N72-11668 02-27)

Avail. NTIS HC \$6.00/MF \$0.95

The conditions that can lead to an explosion within aircraft fuel tank ullages are examined, and the need for protection systems is reviewed. Principles employed in providing the desired degree of protection are outlined, such as oxygen reduction, vapor or mist inerting, and plastic foam fillers. Comparisons were made between the various systems and their relative merits were also discussed. It is concluded that plastic foam is an effective system provided that the material is compatible with the environment. Liquid nitrogen is also attractive from the weight aspect but could impose logistic problems.

Author

N72-11691# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst fuer Luftstrahltriebwerke

# **INVESTIGATION OF FIRE EXTINGUISHING POWDERS BY MEANS OF A NEW MEASURING PROCEDURE**

R. Fiala and G. Winterfeld. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 12 p refs (See N72-11688 02-27)

Avail NTIS HC\$8 00; MF\$0 95

In order to optimise fire extinguishing systems it is necessary to compare the extinguishing efficiency of solid and gaseous (or liquid) extinguishing agents. A measuring procedure is described which allows this direct comparison. It makes use of the relationship between the maximum flow velocity at the burning limit of a flame-holder stabilized flame and the laminar burning velocity of the fuel-air-mixture which is given by DAMKOHLE's first number. Comparative results achieved with this procedure for several fire extinguishing agents are given.

Author

**N72-11692#** Royal Aircraft Establishment, Farnborough (England) Materials Dept

# **SIMULATED CRASH TESTS AS A MEANS OF RATING AIRCRAFT SAFETY FUELS**

R. E. Miller and S. P. Wilford. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 13 p refs (See N72-11688 02-27)

Avail NTIS HC\$8 00; MF\$0 95

Two tests are described for assessing the fire resistance of Avtur containing polymeric additives which reduce its ability to form flammable mists. In the standard test a tank containing ten or twenty gallons of fuel is propelled on a rocket sled at speeds of 114 or 188 ft/sec and decelerated after contact with an aircraft arrester wire. Fuel is allowed to spill from a slit in the tank onto a series of ignition sources. In the run-on test the tank travels at speeds up to 240 ft/sec past a series of ignition sources while spilling fuel from a slit on the leading edge. The velocities of spilled fuel relative to the surrounding air which occur in these tests are shown to be comparable to those occurring during survivable aircraft crashes.

Author

**N72-11693#** Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md

# **SURFACE ACTIVE CONSIDERATIONS IN FUEL FIRES**

Richard L. Tuve. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 4 p refs (See N72-11688 02-27)

Avail NTIS HC\$8 00; MF\$0 95

The problem of efficient extinguishment of fires in burning fuels is dealt with. The use of low density water, in the form of foam, is considered as a means of achieving some solutions to the mechanical and physical needs involved. Emphasis is placed on the utilization of fluorocarbon surfactants which combine foam requirements and fuel-water interfacial activities benefiting fire extinguishing action. Recent development and test of these materials are discussed.

D LG

**N72-11694#** General Electric Co., Cincinnati, Ohio Material and Process Technology Labs

# **LUBRICANT AND FUEL INTERACTIONS IN ADVANCED AIRCRAFT GAS TURBINES**

E. N. Bamberger, D. B. Hester, and M. W. Shaysen. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 12 p refs. Sponsored in part by NASA AFAPL and FAA (See N72-11688 02-27)

(NASA-CR-122842) Avail NTIS CSCL 11H

The interactions and relationships between lubricants and fuels and their properties as related to systems in aircraft gas turbine engines are dealt with. Three areas of recent research are cited to illustrate the impact of lubricant and fuels capabilities on modern engines: (1) a study of the influence of lubricant properties on turbine engine design characteristics especially with regard to high speed supersonic applications; (2) the development of a precise and meaningful test procedure for measuring the thermal stability of kerosene fuels; and (3) the evaluation of advanced high temperature lubricating fluids and their effects on engine bearing performance.

Author

**N72-11696#** Esso Development Co. Ltd. Abingdon (England) Research Centre

# **STABILITY OF SYNTHETIC AVIATION GAS TURBINE LUBRICANTS AT HIGH TEMPERATURES**

R. Robson. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 8 p refs (See N72-11688 02-27)

Avail NTIS HC\$8 00; MF\$0 95

The development of ester based synthetic aviation lubricants over the last 20 years is reviewed. Methods of assessing the high temperature stability of the lubricants are described and the main factors controlling stability are discussed. The suitability of alternative synthetic fluids is considered.

Author

**N72-11696#** Institut Francais de Petrole, Grenoble (France)

# **SYNTHESIS AND PROPERTIES OF ESTERS OF TETRA-METHYL-2,2-7,7 OCTANE DIOL-1,8 [LES ESTERS DU TETRA METHYL-2,2-7,7 OCTANE DIOL-1,8 SYNTHESE ET PROPRIETES]**

P. Badegue, B. Sillion, and G. DeGaudemaris. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 8 p refs. *In* FRENCH (See N72-11688 02-27)

Avail NTIS HC\$8 00; MF\$0 95

A diol of the neopentyl type was obtained by a series of simple reactions proceeding from cyano-4 dimethyl-2,2 butyraldehyde. Esters of linear acids and alpha-alpha prime dimethylated acids were synthesized. Their physical characteristics were determined. Thermal stability and resistance to hydrolysis and oxidation in the presence of metals were examined.

Transl. by K P D

**N72-11697#** Rolls-Royce, Ltd., Bristol (England) Engine Div

# **LUBRICANT EXPERIENCE AND DUTIES IN A CIVIL SUPERSONIC GAS TURBINE ENGINE**

E. W. Doherty. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 12 p ref (See N72-11688 02-27)

Avail NTIS HC\$8 00; MF\$0 95

A description is presented of the Olympus 593 Mk 802 oil system generally, and particular reference is given to the design precautions against the oil fire risk, the use of oil in engine failure warning devices, and in engine health monitoring. Current engine test and flight experience with the lubricant is covered especially with respect to oil consumption, high temperature breakdown areas, prevention of oil carbon formation, mixing of lubricants brands, erosion corrosion effects, and policy in approval processes of lubricants.

Author

**N72-11698#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Munich (West Germany) Inst fuer Flugtrieb- und Schmierstoffe

# **EARLY STAGE DETECTION OF OIL CHANGES IN AIRCRAFT ENGINES**

E. Jantzen. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 13 p refs (See N72-11688 02-27)

Avail NTIS HC\$8 00; MF\$0 95

Potential analytical methods for detection of changes in aircraft turbine oils in the early state are reported and their possible advantages and disadvantages as well as their informative value are discussed. In addition the cause of premature or sudden oil changes in an aircraft engine is investigated. A test rig for simulating such oil changes and the results obtained are discussed. In conclusion, the possibilities of a simultaneous wear control of aircraft turbine oils are briefly explained.

Author

**N72-11699#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

# **THERMAL STABILITY OF A TRI-METHYL-PROPANE ESTER BASED LUBRICATING OIL [CHAMP D'APPLICATIONS D'UNE HUILE BASEE SUR UN ESTER DU TRIMETHYLOL-PROPANE]**

F. Reynaud. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 22 p refs. *In* FRENCH-ENGLISH summary (See N72-11688 02-27)

Avail NTIS HC \$8.00 MF \$0.95

Following a general discussion on the increased performance requirements of lubricating oils made mandatory by increased operating temperatures, the operational possibilities of a tri-methyl-propane ester in two domains of application are described. The first area of application considered was a conventional circuit with oil temperature around 230 C. By adding appropriate additives, a formula was developed with very satisfactory characteristics, particularly in regard to oxidation corrosion. The second area of usage studied was at the 380 C level. The formula appeared not to be well adapted to the new conditions, with some additions losing their efficiency. However the ester remained valid as a base. D.L.G.

N72-11700# Air Force Systems Command, Wright-Patterson AFB, Ohio. Aero Propulsion Lab.

#### SOLID LUBRICATION FOR AERO PROPULSION SYSTEMS

M. R. Chasman. In AGARD Aircraft Fuels, Lubricants, and Fire Safety. Aug 1971. 13 p. refs. (See N72-11888 02-27)

Avail NTIS HC \$8.00 MF \$0.95

Self contained solid lubricated bearings were developed for application to current and future aircraft propulsion and power generation equipment. The capability for long life operation over a wide range of temperatures in an air environment was demonstrated. The approach was to use solid lubricants as a sacrificial retainer material in 20 mm and 35 mm bore bearings. In some cases stainless steel and titanium shrouds were used to provide added strength to the solid lubricant retainers. Lubricants were selected based on their strength, oxidation, friction, and wear properties. It was necessary to deviate from oil and grease lubricated bearing design to achieve acceptable life. Bearing clearance, number of balls, retainer to land clearance and ball pocket size were optimized. Hundreds and in some cases thousands of hours of life were demonstrated. Author

N72-11701# BP Benzin und Petroleum AG, Munich (West Germany).

#### SYNTHETIC LUBRICANTS FOR SUPERSONIC AIRCRAFT

H. D. Corn. In AGARD Aircraft Fuels, Lubricants, and Fire Safety. Aug 1971. 6 p. (See N72-11888 02-27)

Avail NTIS HC \$8.00 MF \$0.95

Classifications and characteristics of synthetic aero turbine oils are reviewed. These oils are classified as type 1 and type 2 lubricants. The type 1 lubricants are defined as blends of a diester basestock and an additive package. Although still being used in jet engines, their use in advanced turbines is considered to be limited by marginal resistance to thermal and oxidative stress. Type 2 lubricants, developed to meet the increased requirements of more sophisticated aircraft, are defined as blends of a hindered tri- or tetraester basestock and an additive package. The burden placed on these lubricants by sustained flight at supersonic speeds is discussed, and the development of an advance complex ester lubricant with a novel additive package for Mach 2+ engines is reported. D.L.G.

N72-27811# National Research Council of Canada, Ottawa (Ontario). Fuels and Lubricants Lab.

#### TECHNICAL EVALUATION REPORT ON PROPULSION AND ENERGETICS. PANEL 37TH MEETING ON AIRCRAFT FUELS, LUBRICANTS, AND FIRE SAFETY

R. B. Whyte and L. Gardner. Paris. AGARD. May 1972. 9 p. refs.

(AGARD AR 44). Avail NTIS HC \$3.00

The discussions which took place at a meeting on aircraft fuels, lubricants, and fire safety are presented. The subjects discussed are: (1) fuels production, analysis and testing; (2) fuel handling; (3) lubricants; and (4) fire safety research. It was concluded that from an operational aspect the fuels and lubricants used for aircraft engines are satisfactory up to at least Mach 2.2. It was recommended that additional developments be undertaken to provide refueling systems capable of dealing with larger volumes of fuel at higher rates of flow than exist in present equipment. Author

## 28 PROPULSION SYSTEMS

Includes air breathing, electric, liquid, solid, and magneto-hydrodynamic propulsion. For nuclear propulsion see 22 Nuclear Engineering. For basic research see 23 Physics General, and 33 Thermodynamics and Combustion. For applications see 31 Space Vehicles. For related information see also 27 Propellants.

**N71-17372#** Advisory Group for Aerospace Research and Development, Paris (France)

### HIGH TEMPERATURE TURBINES

Jan 1971. 587 p. refs. Presented at the 36th Meeting of the AGARD Propulsion and Energetics Panel, Florence, 21-25 Sep 1970.

(AGARD CP-73-71) Avail NTIS HC\$6.00 MF\$0.95

Cooling techniques for turbine blades of high temperature aeronautical gas turbine engines. Advanced cooling methods and the application of improved heat resistant materials are discussed. For individual titles, see N71-17373 through N71-17404.

**N71-17373#** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

### HIGH ENTRY TEMPERATURE TURBINE ON TURBOREACTORS AND GAS TURBINES [DES HAUTES TEMPERATURES DEVANT TURBINE SUR TURBOREACTEURS ET TURBINES A GAZ]

P. Alesi. In AGARD High Temp Turbines, Jan 1971. 14 p. In FRENCH. (See N71-17372 07-28)

Avail NTIS HC\$6.00 MF\$0.95

High entry temperatures for gas turbine engines decrease specific wear and always augment reduced pressures so that gas turbines can compete with Diesel engines in operational performance. Studies on turbocompressors with increased inlet temperatures showed that specific power in simple and double fluxes of moderate expansion increased and that all compressor double flux expansion rates were augmented threefold. Increased temperatures at turbine inlets augment compression and improve the efficiency of compression diluting elements. Transl. by G.G.

**N71-17374#** National Gas Turbine Establishment, Pyestock (England)

### HEAT TRANSFER CALCULATIONS FOR TURBINE BLADE DESIGN

J. Dunham and J. P. Edwards. In AGARD High Temp Turbines, Jan 1971. 18 p. refs. (See N71-17372 07-28)

Avail NTIS HC\$6.00 MF\$0.95

The operating temperature of a cooled turbine blade depends on the heat transfer rate from the hot gas stream, the heat conduction within the metal, and the heat convection to the cooling air. Discussed are methods of calculating these factors, and their application to blade design. The effect of cooling on turbine performance is also considered. Author

**N71-17375#** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

### TEMPERATURE DETERMINATIONS IN THE BLADES OF CONVECTION COOLED TURBINES [DETERMINATION DES TEMPERATURES DANS LES AUBES DES TURBINES REFROIDIES PAR CONVECTION]

G. Union. In AGARD High Temp Turbines, Jan 1971. 13 p. refs. In FRENCH. (See N71-17372 07-28)

Avail NTIS HC\$6.00 MF\$0.95

A mathematical method is presented for calculating the temperature distribution in a convectively cooled turbine blade by considering the temperature constraints imposed on blade life in

the estimation. Comparison between experimental and theoretical results verify the validity of this method for short and median length operations. Transl. by G.G.

**N71-17376#** Rolls-Royce Ltd., Bristol (England). Bristol Engine Div.

### OLYMPUS 593 TURBINE COOLING

M. J. Holland. In AGARD High Temp Turbines, Jan 1971. 21 p. refs. (See N71-17372 07-28)

Avail NTIS HC\$6.00 MF\$0.95

Turbine cooling effectiveness and efficiency are defined for subsequent use in descriptions of cooling performance. The factors affecting the choice of cooling design point and the sources of cooling air are discussed. In particular, the use of 5th stage HP compressor air in place of compressor delivery air is shown to result in lower rotor blade temperatures for the HP turbine. The differing environments and requirements for turbine stator and rotor blades are discussed, together with the importance of combustion chamber outlet gas temperature profiles. The turbine rotor and stator blades are convection cooled and are fairly conventional. The evolution of the various blade cooling designs is described together with summaries of their cooling performance. Author

**N71-17377#** Sussex Univ., Brighton (England). School of Applied Sciences

### HEAT TRANSFER INSTRUMENTATION

A. B. Turner. In AGARD High Temp Turbines, Jan 1971. 18 p. refs. (See N71-17372 07-28)

Avail NTIS HC\$6.00 MF\$0.95

A brief review of heat transfer instrumentation with particular attention to the requirements of the gas turbine engineer is presented. The work is focused primarily on heat flux meters, recent developments in methods of temperature measurement and thermocouple installation errors. In this latter section a numerical procedure for the problem of sensors embedded in insulation channels is presented together with some correlations and predictions for typical examples in solid and porous surfaces. Author

**N71-17378#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

### HEAT FLUX MEASUREMENTS ON FIXED TURBINE BLADES [MESURES DE FLUX DE CHALEUR SUR AUBES FIXES DE TURBINES]

Jacques Michard. In AGARD High Temp Turbines, Jan 1971. 9 p. refs. In FRENCH-ENGLISH Summary. (See N71-17372 07-28)

Avail NTIS HC\$6.00 MF\$0.95

Experimental results obtained on a set-up including a moderately high temperature combustion chamber (1300 K) and two stages of fixed blades are presented. The first stage is used as a distributor, the other one turning the flow parallel to its upstream direction at the outlet. Heat transfer and total exchange coefficients obtained with an upstream Mach number of 0.2 and a Reynolds number of 25,000 per cm are analyzed. Author

**N71-17379#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Luftsaugende Antriebe

### TEMPERATURE MEASUREMENTS WITH THERMOCOUPLES INCLUDING ERRORS CAUSED BY CATALYTIC EFFECTS

P. Stottmann. In AGARD High Temp Turbines, Jan 1971. 10 p. refs. (See N71-17372 07-28)

Avail NTIS HC\$6.00 MF\$0.95

Several methods for the temperature measurement in combustion gas are discussed, especially the interference with thermocouples. Corrections for compensation of the influences due to flow velocity, radiation, and heat conduction are described. In case of using noble metal thermocouples the possible errors by catalytic effects are studied. Experimental results are presented which show the ignition of a fuel-air mixture outside the boundary

layer of the probe, initiated by the catalytic influence of the platinum surface. The reproducible catalytic effects, which initiate or force reactions in a gaseous fuel-air mixture are dependent on the external flow conditions: gas temperature, gas velocity, fuel-air ratio, and the distribution and evaporation of the fuel. Coating the noble metal surfaces with  $Al_2O_3$  avoids the catalytic effects. Author

**N71-17380#** Von Karman Test for Fluid Dynamics, Rhode Saint-Genese (Belgium)

**DESIGN OF SMALL DIMENSION TURBINE BLADE BY THEORETICAL ANALYSIS (DESSIN D'UNE AUBE DE TURBINE DE PETITE DIMENSION AU MOYEN DE PROCEDURES THEORIQUES)**

C. Loidet. In: AGARD, High Temp Turbines, Jan. 1971, 28 p. refs. In FRENCH. ENGLISH Summary. (See N71-17372-07-28.) Avail. NTIS HC\$6.00 MF\$0.95

The method of blade boundary layer optimization due to Le Foll is used for the calculation of a small turbine blade in incompressible flow, with Goldstein's method for the resolution of the inverse potential flow problem. A blade with a cusped trailing edge has been calculated for the following flow conditions: inlet angle 32 deg, outlet angle -54.8 deg and Reynolds number based on the chord and outlet velocity. This blade gives a theoretical loss coefficient based on the dynamic outlet pressure of 4.45%. The calculated losses are in good agreement with the experimental results taking into account the fact that a truly two dimensional flow could not be obtained during the tests. Author

**N71-17381#** United Aircraft of Canada, Ltd., Longueuil, Quebec. **AN EXPERIMENTAL COOLED RADIAL TURBINE**

H. Okamoto and G. S. Calvert. Pratt and Whitney Aircraft, West Palm Beach, Fla. In: AGARD, High Temp Turbines, Jan. 1971, 12 p. (See N71-17372-07-28.) Avail. NTIS HC\$6.00 MF\$0.95

A cooled radial turbine, suitable for compressor drive in a twin spool engine, was designed and is at present undergoing experimental evaluation. Assumed turbine design point conditions were 2300 degrees F inlet temperature, 17-1.2 atmospheres inlet pressure, 4.9 lbs/sec mass flow rate, 5:1 inlet to exit pressure ratio, 220 BTU/lb enthalpy drop, and a rotational speed of 67,000 rpm. Turbine components are nickel alloy castings in which cooling air passages are incorporated. The design features of the turbine and the results of thermal and stress analyses of its components are described. Author

**N71-17382#** Motoren und Turbinen Union, Muenchen G.m.b.H. (West Germany)

**EFFUSION COOLING OF TURBINE BLADES**

H. Prechter, A. Schoenbeck, and N. Scholz. In: AGARD, High Temp Turbines, Jan. 1971, 14 p. refs. (See N71-17372-07-28.) Avail. NTIS HC\$6.00 MF\$0.95

Theoretical and experimental investigations into the aerodynamic and thermodynamic performance of effusion cooled turbine blades are presented. To estimate the aerodynamic and cooling performance an extensive computer programming has been worked out, the physical background of which is described in this report. Few available experimental test results are drawn on to back up the theoretical procedure. Some parametric studies are presented showing the chord and spanwise temperature distributions for an effusion cooled blade with different coolant flow distribution. The cooling effectiveness is investigated for various parametric changes and compared with that of an internally cooled blade. The aerodynamic behaviour reveals a considerable increase in profile loss coefficient of a porous turbine blade both with and without coolant effusion. The effect on overall engine performance by using an effusion cooled high pressure turbine in a modern turbojet engine is briefly discussed. Author

**N71-17383#** Sussex Univ., Brighton (England), School of Applied Sciences

**TRANSPIRATION-COOLED TURBINES**

F. J. Bayley and A. B. Turner. In: AGARD, High Temp Turbines, Jan. 1971, 16 p. refs. (See N71-17372-07-28.) Avail. NTIS HC\$6.00 MF\$0.95

The steps in the development chain of air cooling for gas turbine components and transpiration cooling are described. The three modes of heat transfer involved in transpiration cooling (gas side heat transfer, coolant side heat transfer, and interstitial heat transfer) are discussed separately. Finally, consideration is given to the practical problems of transpiration cooling in advanced gas turbines. Author

**N71-17384#** Curtiss-Wright Corp., Wood Ridge, N.J.

**EXPERIENCE WITH TRANSPIRATION COOLED BLADES**

S. Lombardo and S. L. Moskowitz. Sudavia (in Guerra Aerea), In: AGARD, High Temp Turbines, Jan. 1971, 20 p. refs. (See N71-17372-07-28.) Avail. NTIS HC\$6.00 MF\$0.95

The propulsion system requirements of advanced aircraft necessitate incorporation of significant technological advances in the state of the art of major components in the engine. These advances evolve from the use of advanced design concepts coupled with accelerated testing to substantiate the performance and durability through component and full scale engine testing. Achievement of high turbine inlet temperatures in turbine engines through the use of transpiration air cooled turbine blades is considered. Briefly reviewed are the various transpiration air cooled turbine blades evaluated. This evaluation includes blade design aspects, modes of fabrication, and systems of distribution. The results of component and full scale engine testing up to 3000 F, 1650 C, are also presented. Author

**N71-17385#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

**TURBINE COOLING: ITS LIMITATIONS AND ITS FUTURE**

Jack B. Esquart. In: AGARD, High Temp Turbines, Jan. 1971, 25 p. refs. (See N71-17372-07-28.) NASA TM X-66702; Avail. NTIS CS\$0.21E

The relative merits of convection, transpiration, and full coverage film cooling methods were analytically investigated for a turbine inlet temperature from 2000 to 3500 F, gas pressures from 5 to 40 atmospheres, and cooling air temperatures from 600 to 1200 F. Effects of wall thickness and material temperature were also investigated. Transpiration or full coverage film cooling will probably be necessary to permit operation at turbine inlet temperatures on the order of 3000 F and compressor pressure ratios of 20 or higher. Full coverage film cooling is often superior to transpiration cooling because oxidation problems with transpiration cooled materials reduce allowable metal operating temperatures. Increasing allowable metal temperature 100 F or reducing cooling air temperature 200 F can do more to improve convection cooling than is possible by improvements in current advanced state of the art convection cooled blade or vane design. Author

**N71-17386#** General Electric Co., Cincinnati, Ohio

**HIGH TEMPERATURE TURBINE DESIGN CONSIDERATIONS**

S. N. Succi. In: AGARD, High Temp Turbines, Jan. 1971, 29 p. refs. (See N71-17372-07-28.) Avail. NTIS HC\$6.00 MF\$0.95

The major technological developments which have made possible the trend towards higher temperatures in modern aircraft gas turbine engines are discussed. The relative importance of manufacturing processes, material developments, cooling techniques, analytical design procedures, rupture and cyclic life calculations, and aero-thermo and mechanical design improvements are discussed along with illustrative examples and technical data. The

need for a balanced design approach is stressed, and examples are given where trade offs can be made. It is noted that the advances in aircraft engines during the last 10 years have been based on the evolution of sound engineering principles, extensive component and engine development, and careful consideration of the operational requirements rather than a tremendous breakthrough or revolutionary concept in any one area. Author

**N71-17387#** Technische Hochschule Aachen, (West Germany) Inst fuer Strahltriebwerke

# **EXPERIMENTAL INVESTIGATION ON A SINGLE-STAGE AIR-COOLED GAS TURBINE**

W. Kuehl. In AGARD High Temp. Turbines, Jan 1971, 14 p. refs. (See N71-17372 07-28)

Avail. NTIS HC \$6.00/MF \$0.95

Temperature measurements made within the convection air-cooled rotor blade of a gas turbine during operation cannot deliver complete information of the temperature field, for the number of measuring points is limited by technical considerations. But by using the analogy between the heat flux and the electric current within a three-dimensional model it is possible to determine the heat flow in a complete blade, i.e. the full temperature field within the blade and also the local gas side and coolant side heat transfer coefficients. This paper describes the way from temperature measurements at the turbine rotor to the complete temperature field within the rotor blade. Author

**N71-17388#** Minnesota Univ., Minneapolis School of Mechanical Aerospace Engineering

# **FILM COOLING WITH INJECTION THROUGH HOLES**

E. R. G. Eckert. In AGARD High Temp. Turbines, Jan 1971, 19 p. refs. Sponsored by NASA and the Navy. (See N71-17372 07-28)

(NASA-CR-116376) Avail. NTIS CSCL 21E

Film cooling with ejection through a row or rows of holes is under consideration for gas turbine blades. Discussed is an analytical approach to the prediction of the effectiveness of this cooling method developed in analogy to a method which proves successful for ejection through a slot and some experimental results which are compared with prediction obtained by this analysis. Author

**N71-17389#** Centre National de Recherches Metallurgiques, Liege (Belgium)

# **MEETING REQUIREMENTS FOR HIGH TEMPERATURE GAS TURBINES A CHALLENGE TO METALLURGISTS**

D. Coutouradis. In AGARD High Temp. Turbines, Jan 1971, 17 p. refs. (See N71-17372 07-28)

Avail. NTIS HC \$6.00/MF \$0.95

Metallurgists involved in the development of materials for high temperature gas turbines are challenged by problems of increasing difficulty leading them to explore continually new areas. Some of the current approaches used for the improvement of cobalt and nickel base alloys are reviewed and illustrated. The scope is not limited to an increase in strength but also to insuring structural stability, hot corrosion resistance, coatability. Processing variables such as hot deformation of normally cast alloys, controlled and directional solidification of conventional or eutectic type alloys, powder metallurgy techniques are evaluated. Author

**N71-17390#** National Gas Turbine Establishment, Pyestock (England)

# **FIBRE STRENGTHENED NICKEL-BASE ALLOY**

A. W. H. Morris and A. Brown. In AGARD High Temp. Turbines, Jan 1971, 15 p. refs. (See N71-17372 07-28)

Avail. NTIS HC \$6.00/MF \$0.95

The development and application of high temperature

composites for gas turbine blading is discussed. Of the currently available reinforcements examined, only tungsten-5% rhenium wire affords acceptable stability in nickel-base alloys and a satisfactory increase in stress-rupture strength, but only by incurring a weight penalty. The maximum volume fraction reinforcement is controlled by composite density and blade geometry, at the low levels imposed the advantage of reinforcement is controlled by composite density and cooled blade. If adopted, fibre reinforcement is likely to be used in solid blades in engine stages where cooling is prohibitive and then only as a selected area reinforcement. Indeed the whole question of application may rest on the thermal fatigue behavior. Laboratory tests on cylindrical specimens indicate very poor thermal fatigue crack resistance. Application of the newer low density single crystal alumina fibre is also discussed. Author

**N71-17391#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

# **THERMO-CHEMICAL PROTECTION OF REFRACTORY SUPERALLOYS FOR AIRCRAFT GAS TURBINES (PROTECTION DES SUPERALLIAGES REFRACTAIRES POUR TURBINES A GAZ AERONAUTIQUES PAR VOIE THERMO-CHIMIQUE)**

Philippe Galmiche. In AGARD High Temp. Turbines, Jan 1971, 12 p. refs. In FRENCH, ENGLISH summary. (See N71-17372 07-28)

Avail. NTIS HC \$6.00/MF \$0.95

A first part of the paper is devoted to a survey of the corrosion problems of refractory materials for gas turbines, as they appear at present in the case of the most advanced superalloys. After recalling briefly the main protection methods of refractory superalloys now in use or under study, the second part of the paper describes the chromalumination method that has been developed. Author

**N71-17392#** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Corbeil (France)

# **MATERIALS DEVELOPMENT FOR HIGH TEMPERATURE TURBINES (EVOLUTION DES MATERIAUX POUR TURBINES A HAUTE TEMPERATURE)**

Robert Brunetaud. In AGARD High Temp. Turbines, Jan 1971, 8 p. In FRENCH, ENGLISH summary. (See N71-17372 07-28)

Avail. NTIS HC \$6.00/MF \$0.95

Turbine blades and vanes work in complex conditions with creep, thermal fatigue, corrosion, erosion, etc. Base cobalt and base nickel alloys are developed for these turbine parts in new processes (vacuum melting, vacuum precision casting, unidirectional solidification). Spectacular advantages are possible with niobium alloys but the problems of niobium coatings are not resolved. Low cycle fatigue has to be considered more than creep aspects in disk fabrication. New techniques of isothermal forging or the use of wrought sintered products are indicated for the manufacturing of modified alloys from materials used for blades. Author

**N71-17393#** Solar, San Diego, Calif.

# **THE COMPOSITION, MICROSTRUCTURE AND PROTECTION AFFORDED BY SEVERAL COMMERCIAL COATINGS ON TWO NICKEL-BASE ALLOYS**

A. R. Stetson and V. S. Moore. In AGARD High Temp. Turbines, Jan 1971, 66 p. refs. (See N71-17372 07-28)

(Contract NAS3-9451)

(NASA-CR-116374) Avail. NTIS CSCL 11F

Six commercially available aluminate coatings were evaluated by simulated firing and environmental testing. The environment was a combustion product of JP-5 fuel and air at 0.25 Mach. Coating performance was assessed by weight change and metallographic methods. Electron microprobe X-ray analysis and, to a limited extent, X-ray diffraction were carried out to identify phases and define compositional differences which could be related to performance. Types of aluminate coatings included in this evaluation program

were those containing significant quantities of (1) silicon, (2) chromium applied either before or after the aluminum, and (3) ceramic material. Coatings were also represented that were hyper- and hypo-stoichiometric in the beta-NiAl system. In general, the coatings with the greatest initial aluminum reservoir (thickness) provided the greatest protection. Hyper- rather than hypo-stoichiometric coatings appeared to provide longer protection at the maximum test temperature. The substrate also influenced coating performance with the coatings on B1900 showing consistently better performance than coatings on IN-100. Author

**N71-17394#** von Karman Inst for Fluid Dynamics, Rhode Saint Genese (Belgium).

**APPLICATION OF FILM COOLING TO GAS TURBINE BLADES**

C. Liess and J. Carnel. In AGARD High Temp Turbines Jan 1971 11 p refs. (See N71-17372 07-28)

Avail NTIS HC\$6 00 MF\$0 95

The injection of a secondary flow into a high velocity main stream was investigated. The secondary flow was heated and injected by a row of inclined holes into a main flow at ambient temperature. The geometry of the injection holes and the main flow velocity corresponded to conditions encountered on real turbine blades. After a brief review of the application of film cooling to gas turbine blades the results of the measurements are presented. The tests concerned the adiabatic wall effectiveness and the flow field downstream of the injection holes. The test results show that approximate two-dimensional flow conditions can be obtained not far downstream of the holes, provided that the spacing to diameter ratio of the holes is small. Author

**N71-17395#** Arizona State Univ, Tempe

**EVALUATION OF FILM COOLING PERFORMANCE ON GAS TURBINE SURFACES**

D. F. Metzger, J. R. Biddle and J. M. Warren. In AGARD High Temp Turbines Jan 1971 10 p refs. (See N71-17372 07-28)

Avail NTIS HC\$6 00 MF\$0 95

Film cooling of gas turbine components is often characterized by relatively short cooled lengths and injection geometries which are dictated primarily by fabrication and stress considerations. For many of the resulting configurations, film cooling information based on adiabatic wall temperatures alone is inadequate for design purposes. In addition, the complexity of the film cooling process makes extrapolation of results from one injection configuration to another uncertain. A transient method is described that has been used to rapidly assess the relative performance of various film cooling configurations. Advantages as well as some inherent disadvantages of the method are discussed. The experimental facilities are described, and typical results are presented for a variety of flush, angled injection ports. Emphasis is placed on recent results obtained for high injection rates with variable injection angle, where the heat transfer is dominated by the film flow and effective heat transfer coefficients are much larger than those associated with the primary flow alone. Author

**N71-17396#** Rolls-Royce Ltd, Derby (England), Aero Engine Div

**NOZZLE GUIDE VAN COOLING: THE STATE OF THE ART**

G. A. Halls. In AGARD High Temp Turbines Jan 1971 19 p ref. (See N71-17372 07-28)

Avail NTIS HC\$6 00 MF\$0 95

Reviewed is the present state of the art on air cooling of nozzle guide vanes in aircraft gas turbines. It shows how the design of the cooling system and manufacturing techniques have changed over the years to keep pace with increased turbine entry temperatures. The compromise has gradually shifted towards tailoring the design of the vane to operate within the limitations of available materials. Author

**N71-17397#** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

**COOLING OF TURBINE DISTRIBUTION BLADES THROUGH IMPACT EFFECT (REFROIDISSEMENT DES AUBES DE DISTRIBUTEUR DE TURBINE PAR EFFET D'IMPACT)**

E. Bassinot. In AGARD High Temp Turbines Jan 1971 19 p refs. In FRENCH. (See N71-17372 07-28)

Avail NTIS HC\$6 00 MF\$0 95

One of the improved methods for turbine cooling is the utilization of the impact effect in generating a discharge flow that allows very sensitive temperature corrections. Discussed are experimental studies that use slotted blades surfaces for distributing cooling air through impacting pressure and theoretical calculations of the effects of certain parameters on the impact. The experimental blade consisted of a heat resistant exterior shell and an inner lining that served as distributor of the cooling air and guided it into the convective cooling regions. The functional motor pressure provided the impact effect. It is concluded that this improved impact cooling method is suitable for distributing blades of advanced turbomachinery. Transl by G.G.

**N71-17398#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

**COOLING OF TURBINE BLADES BY LIQUID METALS (REFROIDISSEMENT DES AUBES DE TURBINES PAR LES METAUX LIQUIDES)**

E. Le Grives and J. Genot. In AGARD High Temp Turbines Jan 1971 20 p refs. In FRENCH, ENGLISH summary. (See N71-17372 07-28)

Avail NTIS HC\$6 00 MF\$0 95

Mass transfer conditions in thermosiphon or evaporative cycles under high centrifugal acceleration are first briefly analyzed. Sodium-potassium alloys are shown to be best suited on account of their heat transfer ability with air-cooled exchangers at the blade roots. A high rotation speed test set-up on which the heat flux on the blades is comparable to that of a real turbine has been extensively used for an experimental study of these processes. Both cycles lead to a temperature drop as high as 650 C at the blade tips with a mass flow rate of cooling air of 10 g per sec/kW. However, several advantages are shown to be expectable for the evaporative cycle in view of its application to high temperature gas turbine cooling. Author

**N71-17399#** Army Aviation Materiel Labs, Fort Eustis, Va

**A FLUID-COOLED 2300 F ENTRY TEMPERATURE AXIAL FLOW TURBINE**

Edward T. Johnson. In AGARD High Temp Turbines Jan 1971 17 p refs. (See N71-17372 07-28)

Avail NTIS HC\$6 00 MF\$0 95

A brief description of the overall program for the design and evaluation of a thermosiphon fluid-cooled axial flow turbine is given. The objective of the program was to demonstrate the thermosiphon system's capability to perform adequately cool at an inlet gas temperature of 2300 F. Although the original objective cooling at 2500 F (1260 C) was achieved, difficulty was experienced in obtaining the aerodynamic efficiency, proper fabrication of the blades, and a specific horsepower of 213 HP/Wa. Despite the aforementioned problems, this program did prove the capability of the annular combustor lined nozzle vanes and fluid-cooled blade cooling system while operating at gas temperatures of 2350-2450 F. Author

**N71-17400#** Rolls-Royce Ltd, Derby (England), Aero Engine Div

**THERMAL FATIGUE (FILM)**

In AGARD High Temp Turbines Jan 1971 9 p (See N71-17372 07-28)

Avail NTIS HC\$6 00/MF\$0 95

The incidence of thermal fatigue in cooled turbine blades is illustrated. Problems of this nature have recently been encountered and it is demonstrated how a means of overcoming such problems without resorting to expensive and time consuming rig testing can be provided. Author

**N71-17401#** National Gas Turbine Establishment, Pyestock (England);

**SOME MECHANICAL DESIGN PROBLEMS OF TURBINE BLADES AND DISCS**

J. B. Bullard and B. B. Baxendale. In AGARD High Temp Turbines Jan 1971 19 p refs (See N71-17372 07-28)

Avail NTIS HC\$6 00/MF\$0 95

Internally air-cooled turbine rotor blades usually have a non-uniform temperature distribution. The non-uniform stress pattern thus created is redistributed by creep occurring, at different rates within the blade depending on the local value of stress and temperature. The effect of this process on the blade life is discussed and experiments to check the validity of some of the assumptions are described. The stress patterns in rotating discs are modified when plastic strain occurs dependent on the strain-hardening characteristics of the disc material. This places limitations on the use of conventional material properties as design data. These limitations and the effect of the material stress-strain curve on stress redistribution are discussed. Author

**N71-17402#** Air Force Systems Command, Wright-Patterson AFB Ohio

**AIR FORCE AERO PROPULSION LAB. AIR-COOLED TURBINE DESIGN CRITERIA**

Jack Richens. In AGARD High Temp Turbines Jan 1971 6 p (See N71-17372 07-28)

Avail NTIS HC\$6 00/MF\$0 95

A new technology for gas turbine engines is developed and applied in new engines. In order to accomplish this a phased development cycle has been established that permits high levels of risk in the early stages of development reducing to low levels of risk prior to commitment of the substantial resources necessary for development for production. The development cycle with particular attention to the design or selection criteria that have been or are being successfully applied to air-cooled turbines is described. Author

**N71-17403#** Rensselaer Polytechnic Inst., Troy, N.Y. Mechanics Div

**STRESS ANALYSIS FOR ELEVATED TEMPERATURE LOW-CYCLE FATIGUE WITH HOLD-TIME**

Erhard Krempel. In AGARD High Temp Turbines Jan 1971 17 p refs (See N71-17372 07-28)

Avail NTIS HC\$6 00/MF\$0 95

The behavior of structural materials under simulated service conditions at elevated temperature is shown to be characterized by strain rate (frequency) sensitivity, creep, relaxation and cyclic hardening or softening. These phenomena and prior deformation history have a considerable effect on the subsequent deformation and fracture behavior. A realistic stress analysis for elevated temperature low-cycle fatigue with hold-time has to consider these material properties so that the stresses can be computed throughout the component as a function of time. It is shown that none of the conventionally used descriptions of material behavior (elasticity, plasticity, creep or viscoelasticity) can reproduce all the important observed phenomena. A new approach is proposed which considers time dependent, nonlinear, and history effects. Author

**N71-17404#** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

**TECHNOLOGICAL ASPECTS OF TURBINE BLADE COOLING BY AIR FILM [LES ASPECTS TECHNOLOGIQUES DU REFROIDISSEMENT DES AUBES DE TURBINE PAR FILM D'AIR]**

Jacques M. Ebertrand. In AGARD High Temp Turbines Jan 1971 18 p (See N71-17372 07-28)

Avail NTIS HC\$6 00/MF\$0 95

Technological aspects of placing cooling air emission holes in turbine blade tip portions are considered by evaluating mechanical blade resistance, internal duct organization resulting in an air film, and fabrication methods suitable for multiple cooling. Theoretical and experimental studies of the operational problems connected with the multiple hole cooling method for turbine blades prove the validity of the concept for application in technically advanced turbo machinery. Transl. by G. G.

**N71-13177#** Advisory Group for Aerospace Research and Development, Paris (France)

**TECHNICAL EVALUATION REPORT ON THE AGARD PROPULSION AND ENERGISTICS PANEL 34th MEETING. (8TH COLLOQUIUM) ON REACTIONS BETWEEN GASES AND SOLIDS**

S. S. Penner (California Univ., La Jolla) and P. G. Atkinson Jr. (Directorate of Labs., Andrews AFB, Md.). Feb 1971 12 p. Conf. held at Dayton, Ohio, 13-16 Oct 1969.

(AGARD AR 32-71) Avail NTIS

A report of the round table discussion and a critical review of the presentations are given. There was general agreement that the interdisciplinary character of the meeting had led to a fruitful exchange of views by giving new perspectives to the participants on areas of application of their work and on desirable directions for new studies. Author

**N71-22599#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

**HIGH TEMPERATURE TURBINES**

Jack B. Esgar and R. A. Reynolds (Dept. of Ind. Trade and Com., Ottawa). Paris AGARD Feb 1971 7 p refs. Presented at the 36th Meeting of the Propulsion and Energetics Panel, Florence, 21-25 Sep 1970.

(NASA TM-X-67123 AGARD AR 29-71) Avail NTIS CSCL 21E

State of the art review of high temperature turbine technology was provided at this conference. The following topics were covered by papers presented: problems involved in cooling small turbines; application of turbine blade cooling to engines; selection of high temperature and cooled turbine materials; heat transfer measurement techniques; and an evaluation of the techniques of film, convection, and transpiration cooling. E. M. C.

**N71-26951#** Advisory Group for Aerospace Research and Development, Paris (France)

**SMALL GAS TURBINES FOR HELICOPTERS AND SURFACE TRANSPORT**

May 1971 141 p refs

(AGARD-LS-46-71) Avail NTIS

**CONTENTS**

1. MILITARY AND CIVILIAN NEEDS FOR SMALL GAS TURBINES. D. D. Weidhauer (Army Materiel Command, Wash., D.C.) 11 p (See N71-26952 15-28)

2. THE STATE OF THE ART OF SMALL GAS TURBINE ENGINES FOR HELICOPTERS AND SURFACE TRANSPORT. H. H. Langshur and B. J. Palfreeman (United Aircraft of Canada) 16 p refs (See N71-26953 15-28)



3 CYCLES OF A GAS TURBINE P. Alesi and R. Laurens (Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche, France) 11 p (See N71-26954 15-28)

4 ANALYSIS OF SMALL GAS TURBINE ENGINE COMPONENTS E. Schnell (Kloekner-Humboldt-Deutz A.G., Oberursel, West Germany) 23 p refs (See N71-26955 15-28)

5 INDUSTRIAL AND TECHNOLOGICAL PROBLEMS OF SMALL GAS TURBINES FOR HELICOPTERS AND GROUND TRANSPORT R. M. Lucas (Rolls-Royce, Ltd., Watford, England) 13 p (See N71-26956 15-28)

6 APPLICATION TO POWER GENERATION A. L. Jaumotte (Brussels Univ., Belgium) 25 p refs (See N71-26957 15-28)

7 FUTURE DEVELOPMENTS OF SMALL GAS TURBINES J. Melchior (Atelier de Construction d'Issy-les-Moulineaux, France) 35 p (See N71-26958 15-28)

**N71-26952#** Army Materiel Command, Washington, D.C. Ground Mobility Div  
**MILITARY AND CIVILIAN NEEDS FOR SMALL GAS TURBINES**

Donald D. Weidhuner. In AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 11 p (See N71-26951 15-28)

Avail NTIS

The most important consideration in the selection of a power plant for any application is to maximize return on investment, or to maximize cost effectiveness. It must be indicated that the small gas turbine can yield more return or profit while satisfying operational requirements, than other engines, or its choice cannot be justified. The critical requirements of the propulsion systems for helicopters, vehicles, marine craft, electrical power generation, and total energy systems for buildings are discussed, and the engine characteristics necessary for the turbine to be the preferred choice are indicated. Installation requirements and ancillary components, exhaust emission levels and certain other technical goals are specified. Small gas turbines are arbitrarily considered to be less than 2,000 HP or less than 10 lb/sec airflow. Author

**N71-26953#** United Aircraft of Canada, Longueuil (Quebec)  
**THE STATE OF THE ART OF SMALL GAS TURBINE ENGINES FOR HELICOPTERS AND SURFACE TRANSPORT**

H. H. Langshur and B. J. Palfreeman. In AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 16 p refs (See N71-26951 15-28)

Avail NTIS

The current technical and market status of below 1000 SHP turboshaft engines, as applied to helicopters and surface transport are reviewed. Major data are given for the successful engines and comparisons of salient design features are made. Engines now in development are discussed. On the basis of an industry survey, advances to be expected in a 1980 helicopter engine are described and the expectations are critically reviewed. 1980 surface transportation engines are treated similarly, though in less technical detail. The main challenges for the engine designer and manufacturers in the surface transport field are brought out. Author

**N71-26954#** Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)  
**CYCLES OF A GAS TURBINE [CYCLES DE TURBINES A GAZ]**

P. Alesi and R. Laurens. In AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 11 p. In FRENCH (See N71-26951 15-28)

Avail NTIS

The power of a gas turbine is defined by the following four parameters: air flow, overall pressure ratio, turbine inlet temperature, and components efficiencies. The flow depends directly on turbomachine geometry whereas the compression rate is a

cyclic variable. The temperature in front of the turbine is also a cyclic variable but its value is limited by cooling problems of the turbine materials. Compression output and loss are functions of geometry at each cycle stage before flow clearance is minimized through increased compression. It is concluded that the power of a gas turbine is primarily determined by its thermodynamic cycle and its geometrical shape. Transl. by G.G.

**N71-26955#** Kloekner-Humboldt-Deutz A.G., Oberursel (West Germany)

**ANALYSIS OF SMALL GAS TURBINE ENGINE COMPONENTS**

Erwin Schnell. In AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 23 p refs (See N71-26951 15-28)

Avail NTIS

Aircraft gas turbines are to be developed for lowest weight and smallest volume, therefore they are built without utilization of the exhaust heat but for high pressure ratios. For vehicle gas turbines, however, the specific fuel consumption is the determining factor and therefore the heat exchanger is an essential component of the engine. For small gas turbine engines cooled turbine blades can only be used to a limited extent. In certain cases higher efficiencies can be expected with radial turbines than with axial turbines having unfavorable aspect ratios. Two shaft engines (having a free power turbine) compete with single shaft engines, auxiliary attachments (hydraulic torque converter or hydrostatic transmission) render the single shaft engine feasible to be used for traction purposes. Author

**N71-26956#** Rolls-Royce, Ltd., Watford (England) Small Engine Div

**INDUSTRIAL AND TECHNOLOGICAL PROBLEMS OF SMALL GAS TURBINES FOR HELICOPTERS AND GROUND TRANSPORT**

R. M. Lucas. In AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 13 p (See N71-26951 15-28)

Avail NTIS

After considering why a small engine needs to rotate fast, and be made of integral rather than built up parts, some of the consequent vibratory problems are discussed with the conclusion that methods of introducing damping into the system are required. Fuel system limitations due to dirt being the same size for big and small engines limit the use of scaled down large engine designs. Contamination of compressors by foreign objects is similarly more pronounced. A number of workshop problems special to small size are considered and shown to respond to the use of suitable techniques. Finally a glance at some of the costs which don't scale indicate proportionately high launching costs. Author

**N71-26957#** Brussels Univ. (Belgium)  
**APPLICATION TO POWER GENERATION**

Andre L. Jaumotte. In AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 25 p refs. In FRENCH and ENGLISH (See N71-26951 15-28)

Avail NTIS

The applications of gas turbines of low power (below 500 kW) in the fields of aeronautics, industry and space are reviewed and the advantages and drawbacks of gas turbines in comparison with Diesel engines are discussed. The use of small turbines for the combined production of electric and thermal energy is considered. The thermodynamic characteristics of the total energy system are described and a few examples of industrial applications given. Possibilities offered by the use of gas turbines in space research, especially as regards the production of the energy required on board exploration vehicles are outlined. Author

**N71-26958#** Atelier de Construction d'Issy-les-Moulineaux (France)

**FUTURE DEVELOPMENTS OF SMALL GAS TURBINES**

# [DEVELOPPEMENTS FUTURS DES PETITES TURBINES A GAZ]

Jean Melchior. In AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 35 p. In FRENCH and ENGLISH (See N71-26951 15 28)

Avail NTIS

Light engines with powers ranging between 300 and 1500 hp will be essentially used for the propulsion of ground vehicles that is for industrial applications. 15 kg of weight per hp should satisfy most users. A lower weight will be appreciated, of course but not at any cost. Fuel consumption, in particular, will remain an important item in the cost of operation. Besides, the air intake filtering, sound-proofing and exhaust devices are costly and bulky. Since they are proportional to the air flow rate, they will be three times larger for a turbine than for a diesel engine. The cost per hp of present diesel engines remains an objective for the gas turbine to reach. Now, this cost should still decrease considerably with high super charging simultaneously with the weight per hp which should reach 1 kg/hp in the near future. The essential asset of the turbine is its extremely light weight which is however counterbalanced by the heat recovery device. Author

N72-16685# Advisory Group for Aerospace Research and Development, Paris (France)

## INLETS AND NOZZLES FOR AEROSPACE ENGINES

Dec 1971 503 p. refs. Partly in ENGLISH and FRENCH. Presented at the 38th Meeting of AGARD Propulsion and Energetics Panel, Sandefjord, Norway, 13-17 Sep 1971. (AGARD-CP 91-71 UDC 533.697) Avail NTIS HC \$6.00 MF \$0.95

Conference papers are presented on five topics: engine-airplane interference; presentation in wind tunnel testing; thrust vectoring and control; V, STOL inlets and nozzles; supersonic inlets, nozzles, and applications; and subsonic and transonic aeropropulsion. For individual titles, see N72 16686 through N72-16718.

N72-16686# New York Univ., N.Y., Aerospace Lab.  
**REVIEW OF THE CONCLUSIONS OF THE AGARD AD HOC COMMITTEE ON ENGINE AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS**

Antonio Ferré. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971 10 p. (See N72-16685 07-28)

Avail NTIS HC \$6.00 MF \$0.95

A program for the study of problems of engine-airplane interference is outlined. Engine simulators, nozzle design and dynamic characteristics of the inlet are considered. K.P.D.

N72-16687# National Aerospace Lab., Amsterdam (Netherlands)  
**INLETS-AIRPLANE TESTING IN TRANSONIC WIND TUNNELS**

F. Jaarsma. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971 15 p. refs. (See N72-16685 07-28)

Avail NTIS HC \$6.00 MF \$0.95

The results and recommendations on inlet testing in transonic wind tunnels are discussed in detail. Special attention is directed towards mass flow measurements, external drag determination, boundary layer representation for diverters and bleeds, and non-steady flow phenomena in inlets. Author

N72-16688# Naval Postgraduate School, Monterey, Calif.  
**NOZZLE AND EXHAUST TESTING IN TRANSONIC FLIGHT REGIME**

Allen E. Fuhs. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971 32 p. refs. (See N72-16685 07-28)

Avail NTIS HC \$6.00 MF \$0.95

A survey of engine-airframe interference is presented. In the early stages of development, wind tunnel tests of nozzles and exhausts were conducted both alone and in models of the afterbody. Thrust measurements were made in test facilities at sea level and various altitudes, followed by flight tests. Drag of

nozzle, boattail, etc.) was determined as well as thrust. Simulation of exhaust of hot and cold gases, ejectors, and powered simulators is an important facet of testing. Nonsteady aerodynamics of internal and external flow and aeroelastic phenomena need to be examined. These topics are discussed for both podded and buried engines. Major conclusions of the study related to exhausts and nozzles are given. Author

N72-16689# Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

## PROBLEMS OF MEASUREMENT ON MODEL OF THE THRUST OF A SUPERSONIC AIRCRAFT AFTER-BODY STANDARD NOZZLES

Bernard Masure. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971 15 p. refs. In FRENCH, ENGLISH summary (See N72-16685 07-28)

Avail NTIS HC \$6.00 MF \$0.95

A technique for wind tunnel measurement, through an upstream cylindrical strut, of the thrust of an afterbody is described. With this measurement it is possible to correct the global measurements made on complete models with simplified hollow nacelles. Precision is checked by various calibrations including tests on a standard convergent-divergent nozzle. Checking and analyzing of results for complex configurations, including a primary convergent nozzle, are based on knowledge of mass flow rates and thrusts of corresponding sonic nozzles. Data concerning such nozzles result from precise tests performed within the atmosphere, without external flow, for a wide variety of shapes. The results are presented and compared with theoretical data. Author

N72-16690# Centre d'Essais de Propulseurs, Saclay (France)  
**TEST METHODS AND EXAMPLES FROM THE PROPULSION TEST CENTER**

Jean-Claude Ripoll and Jean-Bernard Cochetoux. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971 17 p. In FRENCH (See N72-16685 07-28)

Avail NTIS HC \$6.00 MF \$0.95

The Propulsion Test Center is a French government establishment which participates in the development of aeronautical engines, using industrial test methods of flight simulation. Equipment at the facility includes principally exhaust air and gas treatment apparatus (using either electricity or vapor), a complex network of conduits, 8 engine test cells for flight simulation and 7 test jets. Measurements are controlled by a central coordinator. Among tests made on air inlets and nozzles, tests on the Concorde aircraft are noted, as well as those on noise and thrust. Transl. by K.P.D.

N72-16691# National Gas Turbine Establishment, Farnborough (England)

## MEASUREMENT FULL SCALE OF PROPELLING NOZZLE PERFORMANCE IN AN ALTITUDE TEST FACILITY

J. C. Ascough. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971 12 p. ref. (See N72-16685 07-28)

Avail NTIS HC \$6.00 MF \$0.95

Full scale thrust performance tests are described which were made in an altitude test cell on a prototype two stream propelling nozzle fitted to a turbojet engine installed within a simulated aircraft nacelle. The tests were made at conditions representing flight at Mach 2 at 20 km altitude. Nozzle thrust efficiency obtained from these full scale tests was compared with that from a 1/10 scale model test rig. The preliminary analysis gave unexpectedly low full scale efficiencies and, to investigate this, special tests were made with the secondary part of the nozzle removed. As a result of the primary nozzle test, corrections were made to secondary nozzle test points, which yielded satisfactory agreement between full scale and model. Author

N72-16692# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

## INLET ENGINE NOZZLE WIND TUNNEL TEST TECHNIQUES

D N Bowditch. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 16 p. refs (See N72 16685 07 28)  
 (N.A. 1.71\* .67494) Avail NTIS CSCL 200

Experimental investigations of the inlet, engine, and exhaust nozzle of a supersonic propulsion system are described. Exhaust nozzle results are presented which are compared with wind tunnel and flight results to assess the accuracy of flight measurements. Comparisons are also presented for nozzle performance obtained with a cold jet, a powered turbojet simulator, and a solid jet boundary simulator. The effect of the local boundary layer on nozzle performance is also discussed. The need for good dynamic measurements during inlet-engine testing is illustrated for transients such as inlet unstart and engine stall. The transient nature of inlet distortion and its effect on the engine are presented for two different operating conditions. Author

N72-16693\* National Research Council of Canada, Ottawa (Ontario) Div of Mechanical Engineering  
**WIND TUNNEL TESTING OF V STOL ENGINE MODELS. SOME OBSERVED FLOW INTERACTION AND TUNNEL EFFECTS**

R A Tyler and R G Williamson. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 12 p. refs (See N72 16685 07 28)

Avail NTIS HC \$6 00 MF \$0 95

The interpretation of force measurements on V STOL related models incorporating inflows and/or outflows is discussed in relation to investigations concerned mainly with the transition performance of lift fan configurations. These utilize balance-mounted, powered models of about 1000 hp in the closed test section of a 10 ft x 20 ft V STOL propulsion tunnel. With models producing strong downwash, an overriding testing limit arises in closed wind tunnels from the formation of a stable floor vortex system due to the interaction of stagnating model flow with the mainstream. An experimental study of this effect as it relates to downward directed jets is described. Vortex formation limits are correlated in terms of a jet force coefficient for a wide range of jet inclinations to the vertical, and for both single and paired jets. Interference velocity measurements, with limited data from the main program and other sources, are used to deduce corresponding tunnel flow breakdown limits. These testing limits are shown to be sensitive to model characteristics. Author

N72-16694\* LTV Aerospace Corp. Dallas, Tex  
**VECTORED THRUST IN AIR COMBAT**

C R James. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 8 p. ref (See N72 16685 07 28)  
 Avail NTIS HC \$6 00 MF \$0 95

Advantages of thrust vectoring in air combat are evaluated using a manned air combat simulator. This simulator consists of two fighter cockpits linked by digital computer driven visual displays which present each pilot with a properly oriented image of the opponent aircraft. Real time digital computation permits each pilot to fly his aircraft anywhere within the performance and strength limits of the airframe as he strives to maneuver into position to fire his weapons. Engagements include three cases: (1) a baseline conventional fighter, (2) a vectored thrust version of the baseline, and (3) the vectored thrust configuration with a 1500 pound weight penalty. The conventional fighter is the common opponent for all engagements. Engagements are scored by relative time in advantageous positions and by win/lose/draw results. Advantages of thrust vectoring are quantified and the sensitivity of advantages to weight penalty is determined. The experiments are described, results are summarized and analyses presented based on aircraft performance parameters. Results are also correlated with previous experiments. Author

N72-16695\* Motoren Und Turbinen Union Muenchen GmbH (West Germany)  
**AERODYNAMICS OF THRUST REVERSER DESIGN**  
 W J Lewis (Rolls Royce Ltd. Bristol, Engl) and H Prechtler. In

AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 11 p. ref (See N72 16685 07 28)  
 Avail NTIS HC \$6 00 MF \$0 95

For a number of applications the clamshell target type thrust reverser is an attractive solution for producing a braking force from a jet engine. This type of reverser consists of a pair of buckets which in the stowed position form part of the aircraft fuselage or engine nacelle and are moved into the jet efflux downstream, from the final nozzle to provide thrust reversal. The important geometric design parameters can be determined from consideration of the flow in the thrust reverser system. Their effect on the aerodynamic performance was established from model tests and is discussed in detail. For the optimization of the operating mechanism in connection with fail-safe requirements, the load on the bucket and its point of application is important and is related to the reverser geometry. The problem of hot gas and debris ingestion into the engine intake is pointed out. Several solutions to overcome this problem are investigated together with the implications they have for performance and design. Author

N72-16696\* Societe Nationale d'Etude et de Construction de Moteurs d'Aviation Villaroche (France)  
**INFLUENCE OF CERTAIN CHARACTERISTIC PARAMETERS ON EJECTOR PERFORMANCE**

Jean Marie Hardy. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 12 p. refs. In FRENCH (See N72 16685 07 28)

Avail NTIS HC \$6 00 MF \$0 95

The optimization parameters for the adaptation of an afterbody are presented and the principles of the theoretical calculation method for ejector performance are considered. A study of the effects of geometric parameters on internal and external nozzle performance is reviewed, based on the results of theoretical and experimental calculations. The internal adaptation of the ejector was investigated, as well as the choice of position for secondary ventilation, considering the effect of hot gas. Optimization of global performance by choosing the value and form of the ejector section are also presented. Several theoretical and experimental results are given. Transl. by K P D.

N72-16697\* Royal Aircraft Establishment Bedford (England)  
**SOME APPLICATIONS OF BOUNDARY LAYER CONTROL BY BLOWING TO AIR INLETS FOR V STOL AIRCRAFT**

I McGregor. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 13 p. refs (See N72 16685 07 28)  
 Avail NTIS HC \$6 00 MF \$0 95

The use of jet blowing as a means of boundary layer control in intakes appears to have several advantages for V STOL aircraft. The principles involved are discussed, giving two examples: a two dimensional inlet under static conditions and a ducted lifting fan at low forward speed. Some results of the effects of slot blowing on the behavior of the intakes of a model of a V STOL strike aircraft at subsonic speeds are presented and compared with those obtained using a naturally aspirated suction bleed. It is concluded that boundary layer control by blowing could lead to a small improvement in net thrust and a significant reduction in flow distortion at entry to the compressor. Sensitivity of intake performance to incidence is also much reduced. Author

N72-16698\* De Havilland Aircraft Co. Ltd. Downsview (Ontario)  
**SOME ASPECTS OF PROPULSION FOR THE AUGMENTOR WING CONCEPT**

U C Whitley. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 14 p. refs. Sponsored in part by NASA (Defense Res. Board of Canada and Canadian Dept. of Ind. (See N72 16685 07 28)

(NASA CR 125540) Avail NTIS CSCL 21E

Many modern concepts for STOL and V-STOL aircraft rely on integration of the propulsion system with the wing to create favorable lift interactions, and are known as powered lift concepts. A study of powered lift, concerning management and control of the various propulsive streams or jets is presented, each concept having its own particular objectives and requirements. Some specific objectives of this kind are described which relate to the augmentor wing. Consideration is given to three aspects of the subject, namely the augmentor flap itself, the wind ducting and augmentor primary nozzle, and the choice of powerplant or engine cycle. More generally, comments are made regarding noise attenuation and the prospect for achieving a low overall noise level for jet STOL aircraft of the future.

Author

**N72-16699#** Rolls Royce Ltd. Derby (England) Engine Div  
**RAPID MIXING NOZZLES FOR V-STOL APPLICATIONS**

C. M. Chesters. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 11 p. refs (See N72 16685 07-28)  
Avail NTIS HC \$6.00 MF \$0.95

If the maximum potential of a V-STOL aircraft is to be achieved, it must be capable of operating from a variety of both prepared and unprepared sites. The use of high thrust to weight ratio jet lift engines with convergent or annular nozzles restricts this capability due to ground erosion, debris and hot gas recirculation and noise. Model and full scale tests demonstrated the benefits to be obtained from the use of rapid mixing nozzles with acceptable thrust loss and engine length penalties. The scope of the investigation extended to an examination of the possibilities of thrust vectoring and of the performance of thrust augmentors using rapid mixing nozzles.

Author

**N72-16700#** Deutsche Forschungs- und Versuchsanstalt fuer Luft und Raumfahrt Brunswick (West Germany) Inst fuer Luftsaugende Antriebe Eng. Dec 1971. 10 p.  
**THE PROPULSION JET OF A VTOL AIRCRAFT**  
E. Schwantes. In AGARD Inlets and Nozzles for Aerospace refs (See N72 16685 07-28)  
Avail NTIS HC \$6.00 MF \$0.95

The three regions of a vertical takeoff propulsion jet (the free jet, the wall jet and the zone of separation of the wall jet from the ground due to wind effects and buoyancy forces) were investigated with a three dimensional model jet. Behind the convergent nozzle the jet accelerates up to supersonic velocity maintaining the core nearly five nozzle diameters. Because of the lower turbulence of the jet with high speed jet decay and the three dimensional spread are lower than those of the jet with small nozzle velocity. At the hot wall jet there is a strong influence of nozzle distance from the ground on velocity profile. The decisive parameter characterizing the recirculation flow is the radius of separation of the wall jet from the ground. The behavior of the radius of separation for different jet parameters and several wind velocities is presented.

Author

**N72-16701#** Von Karman Inst. for Fluid Dynamics, Rhode Saint Genese (Belgium)  
**FLOW ANALYSIS IN AXISYMMETRIC SUBSONIC INLETS OF SMALL GAS TURBINES**  
P. M. Gallet. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 15 p. refs. Prepared in cooperation with Ecole Royale Militaire (See N72 16685 07-28)  
Avail NTIS HC \$6.00 MF \$0.95

Complicated axisymmetric air inlets are used in small gas turbines, thus disturbing the flow at the compressor entrance. A streamline curvature method to calculate the flow in the passage and at the compressor eye is presented. A universal theory of the discontinuities of curvature was applied. Additional annulus boundary layer calculations may help in the analysis of a channel. Some experimental and theoretical results are shown which tend to confirm the validity of the theory.

Author

**N72-16702#** National Research Council of Canada, Ottawa (Ontario) Div. of Mechanical Engineering  
**FLOW DISTORTION AND PERFORMANCE MEASUREMENTS ON A 12 INCH FAN-IN-WING MODEL FOR A RANGE OF FORWARD SPEEDS AND ANGLE OF ATTACK SETTINGS**

Uwe W. Schaub and Robert W. Bassett. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 13 p. refs (See N72 16685 07-28)  
Avail NTIS HC \$6.00 MF \$0.95

The model comprising a 12-in. diameter fan buried in a NACA 0015 section wing with a constant chord of 40 in., was tested at various angles of attack and air speeds in the 10x20 ft closed propulsion wind tunnel. Tunnel interference corrections were estimated. Typical corrections were indicated for the whole testing range which became limited at very low crossflow ratios as a result of uncertainty in the correction in angle of attack. Flow distortion due to crossflow occurred in both the inlet and exit planes. In the crossflow ratio range zero to 0.27 inflow distortion was observed to be velocity distortion at essentially constant total pressure, whereas outflow distortion appeared to be a distortion of the exit plane static pressure field.

Author

**N72-16703#** Boeing Co., Seattle, Wash.  
**THE DESIGN, DEVELOPMENT, AND TESTING OF A SUPERSONIC TRANSPORT INTAKE SYSTEM**  
E. Tjonneland. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 17 p. refs (See N72 16685 07-28)  
Avail NTIS HC \$6.00 MF \$0.95

The performance criteria, including engine airflow matching requirements of an axisymmetric mixed-compression intake for a supersonic transport application are described and related to the selection of the design features of the intake variable geometry components. Viscous technology is applied to the design and development of the boundary layer control system to account for intake viscous interactions and to scale model results to full scale designs. Small, low angle bleed holes 20 deg to the surface yield high flow coefficients. Hole diameters of approximately half the height of the boundary layer displacement thickness are used to improve the cleanliness of the supersonic diffuser flow and to maximize pressure recovery of the bleed air. Vortex valves are incorporated in a fluidic normal shock stability system to allow operation at peak intake recovery and remain started during atmospheric or engine transients.

Author

**N72-16704#** National Gas Turbine Establishment, Pyestock (England) Engine Test Dept.  
**FREE-JET TESTS OF A FULL SCALE SUPERSONIC INTAKE ENGINE COMBINATION**  
P. F. Ashwood. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 19 p. refs (See N72 16685 07-28)  
Avail NTIS HC \$6.00 MF \$0.95

Results are presented from an experimental investigation on a full scale Concorde power plant in 5 ft x 5 ft free jet test facility to investigate intake engine compatibility at supersonic speeds under both steady state and transient conditions. The main aim of the test program was to study the behavior of the power plant when running under the control of its flight systems, in particular during the transients that result from the sudden application of side slip or from rapid engine power changes. Initial tests with the intake alone enabled surveys to be made of the engine face pressure distribution and fluctuation over a wide range of test conditions. The major part of the program was undertaken with an Olympus 593 two spool turbojet engine coupled to the intake in a test configuration which reproduced the precise geometry of the port outer power plant of the prototype Concorde aircraft.

Author

**N72-16705#** British Aircraft Corp., Filton (England) Commercial Aircraft Div.  
**CONCORD POWERPLANT DEVELOPMENT**  
C. S. Leyland and D. P. Morris. In AGARD Inlets and Nozzles for Aerospace Eng. Dec 1971. 32 p. refs (See N72 16685 07-28)  
Avail NTIS HC \$6.00 MF \$0.95

The development of the Concorde power unit is described with particular reference to the problems encountered during flight testing. The extent to which these problems were predicted by altitude test cell experience and the use of such facilities in the development of the design are also discussed. Author

**N72 16706\*** Boeing Co. Seattle Wash  
**CONTROL CONCEPT AND WIND TUNNEL TESTING OF A SUPERSONIC INTAKE CONTROL SYSTEM**  
H. N. Larsen and R. G. Schweikhardt. In AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971. 23 p. refs. (See N72 16685 07 28)  
Avail. NTIS HC \$6.00 MF \$0.95

The controller is independent of other intake controllers and of airplane data systems. During started intake operation throat Mach number is controlled with a translating centerbody and variable position cowl throat doors. normal shock position is controlled with secondary air valves and overboard bypass doors. These two control loops use intake duct pressure ratio signals for feedback. The desired pressure ratio reference value is scheduled with centerbody position and biased with intake controller error signals to provide for varying intake Mach number and angle of sideslip. Using vortex valves as an auxiliary normal shock stability system, model tests showed that the controller can maintain peak intake recovery while accommodating the required disturbances. Hot and cold day engine intake air flow matching is automatically controlled with increased secondary valve air flow or an intake activated engine rpm trim control. An external compression mode which maintains stable intake air flow with low compressor face distortion provides for unstarted supersonic intake operation. Author

**N72 16707\*** General Dynamics Corp. Fort Worth Tex. Convair Aerospace Div.  
**AN AERODYNAMIC DRAG STUDY OF JET ENGINE NOZZLES**  
Dave Bergman. In AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971. 12 p. refs. (See N72 16685 07 28)  
Avail. NTIS HC \$6.00 MF \$0.95

To aid nozzle analysis in areas where analytical methods are lacking, a wind tunnel program was conducted to investigate and measure the external drag characteristics of several nozzles at both on and off design exhaust conditions. This study involves nozzles of the centerbody plug, the convergent and the convergent-divergent types. Flow through nacelle nozzles and solid wall jet plume simulators, each used frequently in airplane model tests, were included in the program. Results show large changes in external drag with variations in exhaust flow and describe the behavior of jet plume shape and entrainment effects. The results also provide insight into methods for simulating exhaust flow effects on airplane models which do not incorporate high pressure exhaust flow. Author

**N72 16708\*** British Aircraft Corp. Preston (England)  
**JET EFFECTS ON BOATTAIL PRESSURE DRAG AT SUPERSONIC SPEEDS**  
J. A. P. Stoddart. In AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971. 11 p. refs. (See N72 16685 07 28)  
Avail. NTIS HC \$6.00 MF \$0.95

An analysis is presented of supersonic boattail pressure drag measurements in the presence of single or twin propulsive jets. Using theoretical inviscid pressure distributions as a datum, the decrease in boattail pressure drag coefficient with increasing nozzle pressure ratio is shown to be a function of the difference between the measured base pressure coefficient and a reference base pressure coefficient. The boattail shapes are divided into two groups, one of which experiences a much stronger influence of the propulsive jet than does the other. Correlations of measured base pressure coefficient in the presence of a propulsive jet are also presented for convergent and conical nozzles. Author

**N72 16709\*** National Aeronautics and Space Administration Flight Research Center, Edwards Calif.  
**A FLIGHT INVESTIGATION OF STEADY STATE AND DYNAMIC PRESSURE PHENOMENA IN THE AIR INLETS OF SUPERSONIC AIRCRAFT**  
Frank W. Burcham Jr. and Donald R. Bellman. In AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971. 12 p. refs. (See N72 16685 07 28)  
NASA TM X 67495. Avail. NTIS CSC 200

The difficulty of achieving adequate inlet performance and stability and avoiding engine compressor stalls at supersonic speeds has led to the investigation of pressure phenomena in the inlets of several supersonic aircraft. Results of tests with the F 111A airplane are presented showing the inlet steady state and dynamic performance. The inlet total pressure distortion that causes compressor stall is discussed, and the requirement for high response instrumentation is demonstrated. A duct resonance encountered at Mach numbers near 2.0 is analyzed and shown to be due to a normal shock oscillation at the duct fundamental frequency. Another type of resonance in the engine fan duct is shown to be a possible cause of reduced engine stall margin in afterburning operation. Plans for a comprehensive inlet study of the YF 12 airplane are discussed including flight tests and full scale 1/3 scale and 1/12 scale wind tunnel tests. Author

**N72 16710\*** Air Force Flight Dynamics Lab. Wright Patterson AFB Ohio  
**SUPERSONIC INLET PERFORMANCE AND DISTORTION DURING MANEUVERING FLIGHT**  
L. E. Surber and D. J. Stava. In AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971. 18 p. ref. (See N72 16685 07 28)  
Avail. NTIS HC \$6.00 MF \$0.95

Several possible vehicle configurations are presented and discussed to point out inherent advantages and disadvantages in terms of airframe inlet integration and mission accomplishment. Features of the forebody and forebody wing configurations are presented together with wind tunnel test data comparing the inlet flow fields of these models. Techniques are described for design air inlets for the airframe flow fields. It also describes the instrumentation employed to document inlet performance. Air inlet performance and duct flow distortion from wind tunnel tests of different model designs are compared to show the effects of aircraft geometry, air inlet design, and maneuver condition over the 0.6 to 2.5 Mach number range. Author

**N72 16711\*** Pratt and Whitney Aircraft, West Palm Beach Fla.  
**INLET ENGINE COMPATIBILITY ANALYSIS**  
S. H. Ellis. In AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971. 10 p. refs. (See N72 16685 07 28)  
Avail. NTIS HC \$6.00 MF \$0.95

The destabilizing factors considered in compatibility analysis are reviewed. Instrumentation and test techniques are discussed, and examples of compatibility data are given for a propulsion system consisting of a supersonic inlet and a turbofan engine. The primary destabilizing factor, inlet distortion, is measured with high response instrumentation capable of describing complex time variant distortion patterns. The maximum time variant distortions determined from model inlet tests are simulated during component and engine testing to define both loss in stall margin with distortion and the attenuation of distortion as it passes through the engine. The losses in stall margin due to engine causes, such as throttle transients, control tolerances and component interactions, are analyzed by dynamic simulation to identify potential system problems prior to system testing. Attention is focused on potential problems by compatibility audits that show the allocation of stall margin between destabilizing influences and identify areas where component improvement is needed. Author

**N72 16712\*** Politecnico di Milano (Italy). Ist. di Macchine  
**ON THE APPLICATION OF A TIME DEPENDENT TECHNIQUE IN TRANSONIC DOUBLE FLOW NOZZLE SOLUTIONS**

Carlo Osnaghi and Ennio Macchi. *In AGARD Inlets and Nozzles for Aerospace Eng.* Dec 1971. 15 p. refs. (See N72 16685 07 28)

Avail NTIS HC \$6.00/MF \$0.95

A computer program was written which was able to solve axisymmetric inviscid flows contemporarily irrespective of their subsonic, transonic or supersonic nature. Some results relating to a transonic nozzle and a subsonic double flow nozzle are presented and compared with experimental data. Author

N72-16713# Office National d'Etudes et de Recherches Aérospatiales Paris (France)

# VELOCITY DISTRIBUTION AT A SUPERSONIC COMPRESSOR INLET

Bernard Ledoux and Roger Bayot. *In AGARD Inlets and Nozzles for Aerospace Eng.* Dec 1971. 10 p. In FRENCH, ENGLISH summary. (See N72 16685 07 28)

Avail NTIS HC \$6.00/MF \$0.95

A direct method is derived in which the ideal compressible flow in the duct is established for the duct and the cowl shapes. The computed pressure distributions are compared with those on the external shroud and cowl during wind tunnel tests. The velocity distribution in the duct is deduced. An indirect method is also presented starting from the pressure distribution on the external wall and leading to the flow field. The calculation is checked by comparing the streamline corresponding to the set up inlet with the front cowl meridian shape. Author

N72 16714# A.S. Kongsberg Vapentfabrikk (Norway) Gas Turbine Div.

# THE ANALYSIS OF A SUBSONIC AXISYMMETRIC INLET FOR COMPRESSOR MATCHING

R. E. Stanley. *In AGARD Inlets and Nozzles for Aerospace Eng.* Dec 1971. 13 p. ref. (See N72 16685 07 28)

Avail NTIS HC \$6.00/MF \$0.95

The measured velocity distribution for the original inlet is compared to the distribution obtained by a method of numerical analysis. It is shown that the favorable results of this comparison led to the development of the inlet by a method of numerical analysis in preference to a model testing technique. The recommendations are presented together with the results of an experimental analysis of the redesigned inlet configuration. The method of compressor matching is touched upon. Author

N72-16715# Office National d'Etudes et de Recherches Aérospatiales Paris (France)

# STARTING CONDITIONS OF A MIXED COMPRESSION AXISYMMETRIC HYPERSONIC INLET

G. Laruelle and J. Leynaert. *In AGARD Inlets and Nozzles for Aerospace Eng.* Dec 1971. 9 p. refs. In FRENCH, ENGLISH summary. (See N72 16685 07 28)

Avail NTIS HC \$6.00/MF \$0.95

An improved diagram including an elementary representation of the interaction phenomenon is used. By means of this diagram, test data on axisymmetrical inlets at high supersonic speeds are discussed, and the influences of some parameters are calculated. Author

N72-16716# Office National d'Etudes et de Recherches Aérospatiales Paris (France)

# THEORETICAL AND EXPERIMENTAL STUDY OF THE COEXISTENCE OF TWO TYPES OF FLOW IN A CHANNEL WITH CONSTANT CROSS SECTION

Jacques Paulon. *In AGARD Inlets and Nozzles for Aerospace Eng.* Dec 1971. 12 p. refs. In FRENCH, ENGLISH summary. (See N72 16685 07 28)

Avail NTIS HC \$6.00/MF \$0.95

A two-dimensional and an asymmetrical set-up of very similar characteristics, were built to study the coexistence, in a constant section duct, of a supersonic jet inside a subsonic jet. The experimental analysis of the flow, made from pressure readings on the walls and inside the fluid, led to characterizing the actual limits of the two flows, and also the transition domain between them. In the two-dimensional case, the schlieren visualization of the flow confirms the measurements. The theoretical analysis, based on the method of characteristics, confirms the pressure readings. The maximum flaring section differs from the sonic section of the external flow, which may lead to faulty predictions in the case of a contoured ejector. Author

N72-16717# Technische Hochschule Aachen (West Germany) Inst. fuer Strahltriebwerke und Turboarbeitsmaschinen

# A NEW CONCEPT OF THE INLET DESIGN AND OF THE THERMODYNAMIC CYCLE OF THE TURBOJET ENGINE AT HIGH FLIGHT MACH NUMBERS

W. Dettmerring and B. Becker. *In AGARD Inlets and Nozzles for Aerospace Eng.* Dec 1971. 10 p. refs. (See N72-16685 07-28)

Avail NTIS HC \$6.00/MF \$0.95

At high supersonic speeds the efficiency of the inlet strongly depends on the diminution of the Mach number before the normal shock. Theoretical investigations show that this deceleration can be increased by replacing the internal compression in the bladeless channel by a supersonic rotor. Due to the deceleration of the relative flow and the increase of the circumferential velocity from rotor inlet to outlet, a significant augmentation of the static pressure ratio is achieved. Moreover, the Mach number can be decreased by the transfer of mechanical energy to the rotor. After the transition to subsonic velocities in the stator, the energy was returned to the flow either by a conventional compressor, or by a second supersonic rotor accelerating the flow between the combustion chamber and the nozzle. Static pressures and temperatures in this turbojet engine, which operates with subsonic combustion, are comparable to those of the supersonic combustion ramjet. Author

N72-16718# Messerschmitt Boelkow-Blohm G.m.b.H., Munich (West Germany)

# WIND TUNNEL INVESTIGATIONS OF A SUPERSONIC AIR INTAKE WITH VARIOUS AUXILIARY INTAKES AT LOW SPEEDS

Herbert Eibl and Reinhard Friedrichs (DFVLR, Brunswick). *In AGARD Inlets and Nozzles for Aerospace Eng.* Dec 1971. 12 p. (See N72 16685 07 28)

Avail NTIS HC \$6.00/MF \$0.95

In the low speed tunnel, model tests were carried out on a twin-engine aircraft configuration with air intakes located on the upper side of the fuselage next to the trailing edge of the wing. The measurements refer to the flow field in the compressor inlet area of a supersonic intake at which the influence of auxiliary intakes of different shapes were investigated. The results are presented as isobars of the total pressure distribution in the compressor inlet area. The pressure loss and distortion parameters are discussed, strongly dependent on the inflow incidence and on the intake flow mainstream ratio. Author

N72-21819# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio

# TECHNICAL EVALUATION REPORT ON PROPULSION AND ENERGY PANEL 38TH MEETING ON INLETS AND NOZZLES FOR AEROSPACE ENGINES

David N. Bowditch and Rodolfo Monti (Naples Univ.) Paris AGARD Feb 1972. 6 p. refs.

(NASA TM-X 67741, AGARD AR-41) Avail NTIS CSCL 21A

The application and use of inlets and nozzles in aerospace, V-STOL, and hypersonic propulsion systems are discussed. Data cover test techniques and facilities, experimental results from small rig tests to flight tests and theoretical analysis of propulsion system flows. The problems associated with such a system are also discussed. EHW

**N73-19794#** Advisory Group for Aerospace Research and Development, Paris (France)

**BOUNDARY LAYER EFFECTS IN TURBOMACHINES**

J. Surugue, ed. (ONERA, Chatillon-sous-Bagneux, France) Dec 1972 473 p refs In ENGLISH, partly in FRENCH (AGARD-AG-164, AGARDograph-164) Avail NTIS HC \$25.75

Studies dealing with the role of boundary layers in turbomachine design and operation are reported. The areas of investigation include subsonic, supersonic, and transonic flow machines. For individual titles, see N73-19795 through N73-19819.

**N73-19795** Von Karman Inst for Fluid Dynamics, Rhode-Saint-Genese (Belgium)

**ON THE TWO DIMENSIONAL BOUNDARY LAYERS AS THEY APPEAR ON TURBOMACHINE BLADES**

K. C. Papailiou, A. Satta (Cagliari Univ.), and F. Nurzia (Genova Univ.) In AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 1-27 refs (For availability see N73-19794 10-28)

Universal curves were developed which relate general properties of optimized boundary layers suitable for the critical side of a blade, to overall design variables. The problem of maximum deceleration was considered and universal curves were developed which establish the deceleration which can be realized giving a length and the initial conditions for the boundary layer. These universal curves were established for incompressible flow. Using La Foll's method, with the introduction of a typical Mach number as an additional parameter, it should be possible to extend the universal design curves to compressible flow. The effects of curvature on turbulence are discussed and it is shown that Bradshaw's model could be used not only for differential but also for integral methods. Author

**N73-19796** United Aircraft Corp., East Hartford, Conn. Research Labs

**PRACTICAL CALCULATIONS OF TRANSITIONAL BOUNDARY LAYERS**

H. McDonald and R. W. Fish. In AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 29-53 refs (For availability see N73-19794 10-28)

A general finite-difference procedure for computing the behavior of compressible two-dimensional boundary layers is presented together with a turbulence model which allows quantitative predictions of the location and extent of the transition region between laminar and turbulent flow as it is influenced by such disturbances as surface roughness and free-stream turbulence. Reverse transition, i.e., relaminarization, caused by large favorable streamwise accelerations, is also quantitatively predicted by this procedure. The solution procedure depends upon the calculation of the streamwise development of a turbulent mixing length whose magnitude is governed by the turbulence kinetic energy equation. A large number of comparisons between predictions and measurements were made and in general very good agreement was obtained. Author

**N73-19797** National Gas Turbine Establishment, Pyestock (England)

**PREDICTIONS OF BOUNDARY LAYER TRANSITION ON TURBOMACHINERY BLADES**

J. Dunham. In AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 55-71 refs (For availability see N73-19794 10-28)

Transition may occur either in the form of natural transition or as a laminar separation bubble ending in reattachment as a turbulent boundary layer. Existing theories of both types are applied to predicting the available transition observations on turbomachinery blading. Owing to the high free stream turbulence level in a turbomachine, many blades must exhibit natural transition, but too few experimental measurements are available to test the predictions adequately. More experiments were conducted involving bubble transition, and after modifying the theory to allow for free stream turbulence predictions agree fairly well with measurements of the position and length of transition bubbles. Author

**N73-19798** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Aerodynamik

**INFLUENCE OF THE DEGREE OF TURBULENCE ON THE AERODYNAMIC COEFFICIENTS OF CASCADES**

R. Kiock. In AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 73-88 refs (For availability see N73-19794 10-28)

An inviscid degree of turbulence is calculated from the circumferential distribution of the potential flow velocity behind a rotating cascade. This is compared with measurements of the degree of turbulence at a stator inlet of a multi-stage axial compressor. Extensive measurements on the influence of the turbulence level on the aerodynamic coefficients of several two-dimensional compressor cascades were carried out. These contained wake traverses, boundary layer measurements and pressure distribution on the profiles. These investigations were carried out in incompressible flow in the range of Reynolds numbers between 90,000 and 270,000 both in slow speed and a high speed cascade wind tunnel. Author

**N73-19799** Detroit Diesel Allison, Indianapolis, Ind

**THE EFFECT OF FREE STREAM TURBULENCE LEVEL ON TURBULENT BOUNDARY LAYER BEHAVIOUR**

G. David Hurfman, D. R. Zimmerman, and W. A. Bennett. In AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 89-115 refs (For availability see N73-19794 10-28)

The results of an experiment to determine the effect of free-stream turbulence level on the classic boundary layer properties indicate the following: (1) The boundary layer thickness increases with increasing turbulence level. This was considered as being due to the increased entrainment brought about by the highly excited state of the boundary between the shear layer and the free-stream. (2) The mean velocity remains largely unchanged in the inner region, however, there is a marked reduction in the wake component as the free-stream turbulence level increases. (3) The skin friction increases with increases in the turbulence level. (4) The shape factor decreases slightly with increased turbulence level due to the reduced wake component. D LG

**N73-19800** Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany)

**ANALYTICAL APPROACH FOR THE LOSS AND DEFLECTION BEHAVIOUR OF CASCADES IN TRANSONIC FLOW INCLUDING AXIAL MASS FLOW VARIATION**

Leonhard Fottner. In AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 113-139 refs (For availability see N73-19794 10-28)

The method described contains a solution of the viscous transonic flow past cascades of slender, slightly cambered profiles, and includes the local supersonic field, the terminal compression shock and a variation of the axial mass flow density across the cascade. The influence of a change in axial velocity across the cascade is considered by introducing additional strips of sources and sinks into the singularity method. Thus, there are induced velocities on the profile surface which have to be added to the surface velocities of the plane case. The local supersonic field which builds up downstream of the sonic point is treated by an empirically corrected supersonic expansion. The location strength of the compression shock terminating the supersonic field downstream is obtained by an empirically corrected normal shock relation. The viscous effect is determined by means of a boundary layer calculation along the profile contour. The problem of interaction between the boundary layer and the normal shock, which is particularly important in the consideration of viscous effects, is closely investigated with the aid of the available test data. The entire flow loss is determined from the shock losses and the profile losses. The latter are obtained from the boundary layer values at the trailing edge with consideration of possible small separation areas and the mixing losses produced in the wake. Author

**N73-19801** Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium)

**BLADE OPTIMIZATION BASED ON BOUNDARY LAYER CONCEPTS**

Shuang Huo *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 141-170 refs (For availability see N73-19794 10-28)

An optimization method based on Le Foll's theory is described. This is an inverse problem where one specifies the optimum boundary layer and obtains the velocity distribution. By using potential methods the corresponding profile or channel shape may be obtained. The calibration procedures for the incompressible and compressible boundary layers are shown. Some examples of the application of the method are given and the work still to be done in the compressible case is discussed. Author

**N73-19802** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst. fuer Luftstrahlantriebe  
**INCOMPRESSIBLE FLOW THROUGH CASCADES WITH SEPARATION**

W. Geller *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 171-186 refs (For availability see N73-19794 10-28)

A singularity method is given for calculating the flow in a cascade with constant blade-surface pressure distribution in the complete region between separation points on the upper and lower surfaces. The contours of blades are replaced by vortex sheets. Source distributions on the contours in the region of separation are used for simulating displacement effects of the separated wake. The position of separation points must be estimated before starting the calculation. Their actual position is found by boundary-layer computation. As shown by comparison of theoretical and experimental results, calculated pressure distributions and flow deflection angles generally agree well with measured data, while the corresponding drag coefficients agree satisfactorily. Author

**N73-19803** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

**INFLUENCE OF ANGLE OF ATTACK AND DEFLECTION ON BOUNDARY LAYER FLOW IN UPRIGHT CASCADE BLADES [INFLUENCE DE L'ANGLE D'ATTAQUE ET DE LA DEFLEXION SUR LE DECOLLEMENT DE LA COUCHE LIMITE DANS UNE GRILLE D'AUBES DE REDRESSEUR]**

Jacques Paulon *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 187-201 refs *In* FRENCH (For availability see N73-19794 10-28)

Cascade blade performance, as affected by boundary layer flow incidence and strong deflection, is examined. Trailing edge flow, backflow and static pressure degradation are analyzed in detail. Transl. by EHW

**N73-19804** Technische Universitaet, Brunswick (West Germany) Inst. fuer Stromungsmechanik

**THE EFFECT OF AXIAL VELOCITY RATIO ON THE AERODYNAMIC COEFFICIENTS OF A COMPRESSOR CASCADE IN VISCOUS FLOW**

U. Stark *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 205-220 refs (For availability see N73-19794 10-28)

Both theoretical and experimental investigations of the effect of axial velocity ratio on the aerodynamic coefficients of two compressor cascades with NACA 65-10106 profiles are described. For the potential flow calculations the Pollard-Horlock method was selected. Boundary-layer calculations were performed based on the potential flow velocity distributions. The aerodynamic coefficients were calculated from the boundary-layer parameters at the blade trailing edge. The experimental investigations were carried out in a low-speed cascade tunnel. Both the theoretical and experimental results show a considerable effect of the axial velocity ratio on the aerodynamic performance of compressor cascades. The agreement between theory and experiment is quite satisfactory in as far as no severe flow separation occurs. Author

**N73-19805** Motoren- und Turbinen-Union Muenchen GmbH (West Germany)

**THE INFLUENCE OF AXIAL VELOCITY DENSITY RATIO ON COMPRESSOR CASCADE PERFORMANCE IN COMPRESSIBLE FLOW**

W. Heilmann *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 221-240 refs (For availability see N73-19794 10-28)

Results of theoretical and experimental investigations on the influence of the ratio between the axial velocity density upstream and that downstream on the performance of plane compressor cascades in compressible flow are presented. Tests were performed in a 7-inch transonic wind tunnel where upstream turbulence levels were varied. It could be demonstrated that the change in cascade performance with the axial velocity density ratio substantially depends upon the blade boundary layer behaviour. At fully turbulent boundary layers the axial velocity density ratio influences only the separation point positions. At laminar-turbulent boundary layers in addition the transition point position from which the separation point positions depend will be influenced. Boundary layer calculations conducted in the theoretical part of the investigation have qualitatively confirmed the experimentally achieved results as far as the influence of the axial velocity density ratio on the transition and separation point position is concerned. Total pressure loss at various axial velocity density ratios was calculated by applying an approximative method of determining the characteristic boundary layer values in separated flow and then comparing with the test results. Author

**N73-19806** Rolls-Royce, Ltd., Bristol (England)

**THE ROLE OF BOUNDARY LAYERS IN AXIAL FLOW TURBOMACHINES AND THE PREDICTION OF THEIR EFFECTS**

N. J. Seyb *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 241-259 refs (For availability see N73-19794 10-28)

The prediction of boundary layer conditions within a turbomachine is reviewed from the engine designer's viewpoint. A brief outline of the problems and compromises forced on the aerodynamicist is given followed by a discussion of the boundary layer prediction methods currently in use. Because of the extremely complicated flow patterns present in a turbomachine only the simplest cases (i.e. flow in two-dimensional cascades) have responded adequately to theoretical treatment. Simple and practical methods are described for the prediction of the boundary layer parameters, transition and laminar separation points, bubble sizes and heat transfer coefficients, etc. for any cascade, incidence, Reynolds number, turbulence level, etc. Comparisons between experiment and prediction are given and it is shown that there is good agreement. Author

**N73-19807** Motoren- und Turbinen-Union Muenchen GmbH (West Germany)

**A CALCULATION METHOD FOR THE EXTERNAL HEAT TRANSFER TO TURBINE BLADES**

D. K. Hennecke *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 261-273 refs (For availability see N73-19794 10-28)

A complex calculation method was devised to predict the local temperature distribution in a cooled turbine blade. The report is devoted exclusively to one of the key elements of the procedure which is an integral type boundary layer analysis to predict the distribution of the external heat transfer coefficient. The analysis has been adapted to the special requirements of turbine blade cooling research. Thus, it accounts for the combined effects of compressibility, laminar as well as turbulent flow regions, favorable and adverse pressure gradients, smooth and/or rough blade surfaces, lateral convergence or divergence, and temperature dependent fluid properties. Furthermore, in the evaluation of the heat transfer coefficient a pressure gradient in flow direction and a longitudinal temperature gradient within the wall are considered. The method also allows injection into the boundary layer, either local (film cooling) or continuous (effusion cooling). Results are presented graphically for a cooled turbine blade with



a certain profile and specified flow conditions. For this example, the various features, listed above, were studied individually and the magnitude of their effects on the heat transfer coefficient is demonstrated.

Author

**N73-19808** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**METHOD OF CALCULATING THREE DIMENSIONAL TURBULENT BOUNDARY LAYER SEPARATION WITH APPLICATION TO A SIMPLE TURBOMACHINE CASE [METHODE DE CALCUL DE LA COUCHE LIMITE TURBOULENTE TRIDIMENSIONNELLE JUSQU'A LA SEPARATION APPLICATION A UN CAS SIMPLE DE TURBOMACHINE]**

R. Michel *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 277-292 refs *In* FRENCH; ENGLISH summary (For availability see N73-19794 10-28)

The proposed method is based on the determination of similarity solutions for three-dimensional turbulent boundary layers: solutions established from an improved mixing length model. The characteristics of the families of streamwise and crosswise velocity profiles obtained in this way are then used in a method for solving boundary layer global equations. Applied and tested previously for aeronautics problems, the technique is extended to treat turbomachinery problems, taking into account, among other things, the effects of rotation walls. The case of the swirling flow in the diffuser of a centrifuge compressor is examined, and the position of separation, i.e. the circle on which the wall streamlines accumulate, is determined as a function of the inlet angle. It is also found that a rotation at the diffuser walls entails a much slower thickening of the boundary layers, and a noticeable recession of separation.

Author

**N73-19809** Institute TNO for Mechanical Constructions, Delft (Netherlands)

**MEASURED AND CALCULATED TURBULENT BOUNDARY LAYER FLOW IN A VANELESS RADIAL DIFFUSER**

C. B. V. D. Voorde and J. Bos *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 293-310 refs (For availability see N73-19794 10-28)

A method is presented for predicting two-dimensional flow through a radial diffuser with flat parallel walls. The method is based on the integral entrainment method and is valid until the flow is fully developed. Equations are given for prediction of the velocity distribution across the diffuser width at any arbitrary station, prediction of the radial distribution of the static pressure recovery, and calculation of the diffuser efficiency from the predicted and measured flow. An experiment conducted for validation of the prediction method is described. During the experiment very accurate measurements were made of the velocity distribution across the constant diffuser width at various stations along a diffuser radius. The experimental values concurred well with predicted values.

D. G.

**N73-19810** Technische Hochschule, Aachen (West Germany) Inst. fuer Strahlentriebe und Turboarbeitsmaschinen

**APPLICATION OF BOUNDARY LAYER FENCES IN TURBOMACHINERY**

H. Pruempfer *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 311-331 (For availability see N73-19794 10-28)

The major secondary flows occurring in turbine stages are presented and their causes and their effect on the total flow are discussed. Through visualization of the flow lines near the wall and accurate measurement of the three-dimensional loss distribution of cascades with short and longer blades, detailed information may be obtained on the mechanism of the secondary flows and the secondary losses thereby produced. In the course of experimental tests aimed at possibilities of suppressing secondary flows and secondary losses incidental thereto, the method of using boundary layer fences on the profile suction sides of the blades proved to be particularly effective and economical. Finally, the experimental results obtained from the application of this method in a turbine stage are presented.

Author

**N73-19811** Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium)

**SECONDARY FLOW RESEARCH AT THE VON KARMAN INSTITUTE**

J. W. Salvage *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 333-361 refs (For availability see N73-19794 10-28)

Experimental work in cascade secondary flows accomplished in the past ten years is reviewed with the objective of pointing out difficulties common to the field. Investigations included tip clearance effects, low aspect ratio effects, and the beginnings of basic research on the influence of blade loading and inlet boundary layer characteristics on common compressor blade profiles. The objective of current investigations is to select critical configurations for in-depth study of the end-wall boundary layer development through the cascade with a view toward refining the experiment for use in the truly three-dimensional environment of a stator row. An initial experiment on end-wall flows is outlined and typical data shown. An improved technique is discussed, including test apparatus and probes to be used. Other topics discussed include an interesting method of reducing secondary flow losses (partial blade slotting) and the critical analysis of a simple, but geometrically limited, theory predicting secondary flow losses at high blade loading conditions.

Author

**N73-19812** Princeton Univ., N.J.

**THE PREDICTION OF AXIAL COMPRESSOR PERFORMANCE WITH EMPHASIS ON THE EFFECT OF ANNULUS WALL BOUNDARY LAYERS**

G. L. Mellor and T. F. Balsa *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 363-374 refs (For availability see N73-19794 10-28)

Current results are summarized in the development of a computer program to simulate axial compressor performance. The program incorporates a new theory of annulus wall boundary layers which predicts annulus boundary-layer development and losses. Aside from the work involved with the construction of the program, considerable effort is being expended to diagnose existing multistage data in terms of the rather simple parameters associated with the annulus boundary-layer theory.

Author

**N73-19813** Cambridge Univ. (England)

**PREDICTION OF ANNULUS WALL BOUNDARY LAYERS IN AXIAL FLOW TURBOMACHINES**

M. Daneshyar, J. H. Horlock, and H. Marsh *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 375-392 refs (For availability see N73-19794 10-28)

Various existing integral boundary layer methods have been examined and their predictions are compared with a wide range of experimental data. The sensitivity of the boundary layer calculations to the mainstream data input has been examined.

Author

**N73-19814** Technische Hochschule, Aachen (West Germany) **ANNULUS WALL BOUNDARY LAYERS IN AXIAL FLOW TURBOMACHINES**

W. Bitterlich and K. Rubner *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 393-413 refs (For availability see N73-19794 10-28)

The influence of annulus wall boundary layers, which differ considerably from ordinary boundary layers, is shown as it affects the entire flow in turbomachines. Starting from the measured velocity distributions, the radial balance in the axial gaps and in the cascade channel of the rotor and stator is established by means of the conservation equations for mass, momentum and energy. The special effects of the transitions between stationary and moving cascades within the region of the annulus wall boundary layers are illustrated. The velocity distributions measured in the boundary layer region are thus explained. In contrast to what had been generally assumed, strong gradients of total enthalpy occur within the boundary layer. For the blade momentum boundary values at the annulus walls and at the mean radius can be indicated, so that a qualitative distribution of blade momentum may be established. The theoretical statements and results have been confirmed by experimental investigations on a single-stage axial flow compressor having a

very small hub-tip ratio. Theory and experiment show clearly that the influence of wall friction is not confined to the boundary layer region but, even with a small hub-tip ratio, affects the entire flow channel. Author

**N73-19816** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**RESULTS OF INTERACTION OF SHOCK WAVE WITH TURBULENT BOUNDARY LAYERS AT MODERATE MACH SUPERSONIC NUMBERS [RESULTATS SUR L'INTERACTION CHOC-COUCHE LIMITE TURBULENTE A DES NOMBRES DE MACH MODEREMENT SUPERSONIQUES]**

J. Delery and J. C. LeBalleur. In AGARD Boundary Layer Effects in Turbomachines. Dec 1972. p 419-440. refs. In FRENCH. ENGLISH summary (For availability see N73-19794 10-28)

Reflection of an oblique shock wave on a turbulent boundary layer was studied experimentally on a two-dimensional plane set-up at two Mach numbers, 1.62 and 1.92. In both cases the upstream flow was uniform and the Reynolds number was around 100,000. The variable parameter was the shock intensity. Particular attention was paid to the set-up design for minimizing the perturbation effects and also for obtaining a good measuring precision, especially for boundary layer probeings. Author

**N73-19816** Von Karman Inst. fo Fluid Dynamics, Rhode-Saint-Genese (Belgium)

**SHOCK WAVE BOUNDARY LAYER INTERACTION IN CASCADES**

H. Griepentrog. In AGARD Boundary Layer Effects in Turbomachines. Dec 1972. p 441-456. refs. (For availability see N73-19794 10-28)

Experimental data obtained with compressor cascades were analyzed to determine the main parameters that affect the shock boundary layer interaction region. These parameters were found to include: (1) the displacement thickness of the boundary layer upstream of the shock, (2) the shock intensity, and (3) the pressure gradient downstream of the shock. Taking these parameters into account, a simple model of the interaction was designed. The model only considers the external effects, such as pressure distribution on the blade surface. The model presented is considered only a tentative one and further research is indicated to understand the interaction of a quasi-normal shock with a turbulent boundary layer in compressor cascades. D L G

**N73-19817** Office National d'Etudes et de Recherches Aérospatiales, Paris (France)

**BEHAVIOR OF BOUNDARY LAYER IN SUPERSONIC STRAIGHT AND ANNULAR BLADE CASCADES, FIXED AND MOBILE [COMPORTEMENT DE LA COUCHE LIMITE SUR GRILLE D'AUBES SUPERSONIQUES PLANES ET ANNULAIRES]**

Jean Fabri and Roland Sovrano. In AGARD Boundary Layer Effects in Turbomachines. Dec 1972. p 457-468. refs. In FRENCH. ENGLISH summary (For availability see N73-19794 10-28)

Fundamental research on supersonic axial flow compressors requires an accurate knowledge of section performances. Straight and annular supersonic blade cascades were used for the investigation, the latter one being either fixed or rotating. The effect of boundary layer development in these blade cascades is described. Schlieren pictures of the flow field and shock configuration as well as pressure distributions on the blades (straight and fixed annular cascades) or on the casing (fixed and rotating annular cascades) were taken. The conclusion from the analysis is that at low backpressure, i.e. started supersonic flow in the cascades, flow configuration and pressure distributions are very similar on all three experimental set-ups. However, at high back pressure, with strong shock waves induced in the blade channel, shock wave-boundary layer interaction is quite different in static and rotating cascades. It seems however that owing to the effect of centrifugal forces induced by flow rotation in the annular cascade, the difference between flow patterns in this type of experimental set-up and on rotors is not very great. Author

**N73-19818** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)

**HIGH SPEED SCHLIEREN FILM OF THE PULSATING FLOW IN A TRANSONIC TURBINE CASCADE**

O. Lawaczeck. In AGARD Boundary Layer Effects in Turbomachines. Dec 1972. p 469-473. refs. (For availability see N73-19794 10-28)

A high speed schlieren film is discussed that was taken in a cascade wind tunnel on a supercritical flow through a special type of a turbine cascade. The flow pattern near the leading edges shows that the upstream flow is stationary although nonstationary effects were noted near the trailing edge. The question is posed as to whether the nonstationary effects are initiated by the disturbances originated by the free jet boundary of the cascade or by the interaction between the trailing edge shock and the wake of the blade. D L G

**N73-24788#** Advisory Group for Aerospace Research and Development, Paris (France)

**RELATIVE AIR POLLUTION EMISSION FROM AN AIRPORT IN THE UK AND NEIGHBOURING URBAN AREAS**

A. W. C. Keddle (Dept. of Trade and Ind., Stevenage, Engl.), G. H. Roberts (Dept. of Trade and Ind., Stevenage, Engl.), and J. Parker (Dept. of Trade and Ind., Stevenage, Engl.) [1971]. 10 p. refs. Repr. from the publ. "Conference Pre-print No. 125 on Atmospheric Pollution by Aircraft Engines". Paris. AGARD. 10 p. Avail. NTIS HC \$3.00

Air pollution levels at Stansted Airport, England, in relation to emissions from four nearby towns are discussed. Calculations have been made of pollution emissions from these four sources and also from the airport, and the expected contributions from these sources at three local sites have been examined. These values are compared with actual measurements at the three sites. Author

**N73-26800#** Advisory Group for Aerospace Research and Development, Paris (France)

**MODERN METHODS OF TESTING ROTATING COMPONENTS OF TURBOMACHINES**

M. Pianko. ed. (Serv. Tech. Aeronaut. Paris). May 1973. 51 p. refs. Partly in ENGLISH, partly in FRENCH. Conf. held at Toulouse. 18-21 Sep. 1972.

(AGARD AG 167. AGARDograph. 167). Avail. NTIS HC \$4.75

The AGARD Propulsion and Energetics Panel conducted a survey on the methods used to test the rotating components of turbomachines. The objective was to assess the advantages and usefulness of the so called elementary tests compared with the tests conducted on complete turbomachines. Based on a detailed analysis of the answers received from the questionnaires and an exchange of views among the experts appointed by the Panel, general conclusions are presented on the value and use of cascade test data, testing and measuring equipment for cascade tests, testing techniques for supersonic compressor cascade tests on compressor or turbine stages, and on a complete compressor or turbine. Reynolds number effects, cold testing of turbines, and compressor stability and distortion tests. Author

## 29 SPACE RADIATION

Includes cosmic radiation, solar flares, solar radiation, and Van Allen radiation belts. For related information see also 13 Geophysics, and 24 Physics, Atomic, Molecular, and Nuclear.

No abstracts in this subject category

Preceding page blank

30 SPACE SCIENCES

275

## 30 SPACE SCIENCES

Includes astronomy and astrophysics, cosmology, lunar and planetary flight and exploration, and theoretical analysis of orbit and trajectory. For related information see also 11 Facilities, Research and Support, and 31 Space Vehicles.

No abstracts in this subject category

## 31 SPACE VEHICLES

includes launch vehicles, manned space capsules, clustered and multistage rockets, satellites, sounding rockets and probes, and operating problems. For basic research see 30 Space Sciences. For related information see also 28 Propulsion Systems, and 32 Structural Mechanics

**N72-12861#** Advisory Group for Aerospace Research and Development Paris (France).

### ATTITUDE STABILIZATION OF SATELLITES IN ORBIT

Sep 1971 152 p refs

(AGARD-LS-45-71) Avail NTIS

#### CONTENTS

- 1 FOREWORD p iii
- 2 SPEAKERS p iv
- 3 INTRODUCTION H Vigneron p vii
- 4 ROTATIONAL DYNAMICS M A Friik (Tech Hochschule, Stuttgart, West Ger) 14 p refs (See N72-12862 03-21)
- 5 SPACECRAFT ATTITUDE SENSORS WITH EMPHASIS ON THE ORBITING ASTRONOMICAL OBSERVATORY T E Huber (NASA Goddard Space Flight Center) 16 p refs (See N72-12863 03-21)
- 6 PASSIVE AND SEMI-ACTIVE ATTITUDE STABILIZATIONS DUAL SPIN SATELLITES P W Likins and P Y Willems (Louvain Univ) 11 p refs (See N72-12864 03-21)
- 7 PASSIVE AND SEMI-ACTIVE ATTITUDES STABILIZATIONS FLEXIBLE SPACECRAFT P W Likins (Calif Univ, Los Angeles) 13 p refs (See N72-12865 03-21)
- 8 ACTIVE STABILIZATION W G Hughes (RAE Farnborough, England) 17 p refs (See N72-12866 03-21)
- 9 STABILIZATION OF EOLE AND PEOLE SATELLITES P Hugquier (Centre Natl D'Etudes Spatiales, Bretigny-Sur-Orge, France) 28 p (See N72-12867 03-21)
- 10 DEVELOPMENT RESULTS OF THE ESRO TD SATELLITE PNEUMATIC SYSTEM W Iden (Erno Raumfahrttechnik Gmb H, Bremen, West Ger) 20 p refs (See N72-12868 03-21)
- 11 THE SIRIO ATTITUDE MEASUREMENT AND CONTROL SYSTEM A Buratti (Compagnia Industriale Aerospaziale S.p.A., Rome, Italy) 14 p (See N72-12869 03-21)
- 12 ATTITUDE CONTROL OF THE APOLLO SPACECRAFT R H Battin (Massach Inst of Tech, Cambridge) 10 p refs (See N72-12870 03-21)

**N72-12862#** Technische Hochschule Stuttgart (West Germany) Inst a fuer Mechanik

### ROTATIONAL DYNAMICS

Martin A Friik. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 14 p refs (See N72-12861 03-31)

Avail NTIS

The fundamentals of the rotational dynamics of satellites are considered. Basic geometric and kinematic relations are reviewed and the Euler equations describing the rotational motion of rigid bodies are derived. The torque free motion of dynamically symmetrical as well as unsymmetrical satellites is investigated, including a stability analysis of permanent rotations about axes of principal moments of inertia. External torques, such as gravity gradient, magnetic, aerodynamic, and solar radiation torques, which are caused by the interaction of an orbiting satellite with its environment, are discussed. Finally, for some types of nonrigid satellites the equations of motion are considered. Author

**N72-12863\*#** National Aeronautics and Space Administration Goddard Space Flight Center, Greenbelt, Md

### SPACECRAFT ATTITUDE SENSORS WITH EMPHASIS ON THE ORBITING ASTRONOMICAL OBSERVATORY

Thomas E Huber. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 16 p refs (See N72-12861 03-31)

(NASA-TM-X 673P4) Avail NTIS CSCL 22B

The sensors that provide references for the OAO control system are coarse sun sensors, fine sun sensors, Adcole aspect sensors, rate and position sensors, inertial reference unit, boresight tracker, gimbal star trackers, fixed head tracker, and magnetometers. The coarse and fine sun sensors are analog type sensors and are part of the OAO control loop. The aspect sensors are digital type and are used with the magnetometers primarily for attitude determination. The inertial sensors are used to slew or reposition the vehicle and are also used to inertially hold the spacecraft. The gimbal trackers and boresight tracker are used for stellar control holding the vehicle to an attitude accuracy of one arc minute. Author

**N72-12864#** Louvain Univ (Belgium) Inst de Mecanique PASSIVE AND SEMI-ACTIVE ATTITUDE STABILIZATIONS: DUAL SPIN SATELLITES

P W Likins and P Y Willems. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 11 p refs (See N72-12861 03-31)

Avail NTIS

Dual-spin systems find space applications in missions for which the ability to point some instruments or a platform with a good spin stabilization is required. The equations of motion of a deformable system including internal moments are derived. The equilibrium configurations of such a system in free space and in an inverse square field are obtained. The attitude stability of a deformable gyrostet, a convenient idealization of a dual-spin satellite, is investigated. The effect of dissipation in both sections of the system is discussed and a rigorous method permitting the stability determination is set forth. Author

**N72-12866#** California Univ, Los Angeles PASSIVE AND SEMI-ACTIVE ATTITUDE STABILIZATIONS: FLEXIBLE SPACECRAFT

Peter W Likins. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 13 p refs (See N72-12861 03-31)

Avail NTIS

The influence of spacecraft nonrigidity is identified as the pre-eminent current problem in attitude stabilization of passive and semi-active spacecraft. Attitude control anomalies in the flight histories of eight satellites are attributed to nonrigidity, manifested either as unexpected internal energy dissipation or unanticipated structural deformations. Recent progress in the development of methods for analysis of flexible spacecraft is surveyed, with attention to discrete coordinate methods, vehicle normal coordinate methods, and hybrid coordinate methods. New results are provided for each of these analytical procedures and the utility of these results is discussed in the context of anticipated future spacecraft. Author

**N72-12836#** Royal Aircraft Establishment, Farnborough (England) Space Dept

### ACTIVE STABILIZATION

W G Hughes. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 17 p refs (See N72-12861 03-31)

Avail NTIS

A survey is given of the principal devices available for the generation of control torque, covering mass expulsion systems (cold gas, hot gas, electric) momentum exchange system (reaction wheels, control moment gyros) and magnetic torques. For reaction wheel systems, the complete linearized equations of motion in three axes the effect of interaxis couplings are studied. Control in a single axis is considered in detail. Mass expulsion and magnetic techniques for momentum unloading are discussed. Control moment gyro systems are described. Pure jet systems are studied from the viewpoint of achieving high precision while preserving economy in the use of jet fuel. Difficulties arising from jet delay and sensor delay and noise are minimized by the use of a signal processing technique which incorporates a model of the spacecraft dynamics. Finally, the special properties of inertially referenced systems are considered together with the gyrocompassing technique for use in earth pointing spacecraft. Author

**N72-12867#** Centre National d'Etudes Spatiales, Bretigny-Sur-Orge (France).

**STABILISATION OF EOLE AND PEOLE SATELLITES**  
**[STABILISATION DES SATELLITES EOLE ET PEOLE]**

Philippe Huguer. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 28 p In FRENCH (See N72-12861 03-31)

Avail. NTIS

The orbits and stabilization simulations of the Eole and Peole satellites are discussed. Various methods, in particular the gravity gradient method, are discussed in detail. The accuracy of the methods was also determined. Data are included for the attenuation, energy dissipation, and the differences calculated for both satellites. Mathematical models are included.

Transl. by E.H.W.

**N72-12868#** Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany)

**DEVELOPMENT RESULTS OF THE ESRO TD SATELLITE PNEUMATIC SYSTEM**

Werner Inden. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 20 p refs (See N72-12861 03-31)

Avail. NTIS

The attitude control requirements and principles of the ESRO TD satellite are reviewed, and the propulsion system are explained. The TD propulsion system is an argon cold gas system with no redundant parts which is based on the life time of 1/2 to 1 year in orbit. The test results of development, qualification, and flight acceptance are illustrated as the influence of the dynamic response on thrust, the problem of leakage and contamination, the regulation as a function of mission time. The successful subsystem qualifications, especially vibration tests, are shown. Development techniques for nozzles, system filling and leakage checkout are described. The performance of the small nozzles (0.02 N) used on TD is shown.

Author

**N72-12869#** Compagnia Industriale Aerospaziale S.p.A., Rome (Italy)

**THE SIRIO ATTITUDE MEASUREMENT AND CONTROL SYSTEM**

Alessandro Buratti. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 14 p (See N72-12861 03-31)

Avail. NTIS

The Sirio attitude measurement and control subsystem components, their characteristics, their interconnection with other units, their mode of operation and how they are employed are described. Component test problems are discussed where appropriate, as in the case of the sensors and of the nutation damper. Emphasis is given to attitude measurement and an estimate of the accuracy which may be achieved both in the transfer and in the geostationary orbit is given.

Author

**N72-12870#** Massachusetts Inst of Tech., Cambridge Charles Stark Draper Lab.

**ATTITUDE CONTROL OF THE APOLLO SPACECRAFT**

Richard H. Battin. In AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 10 p refs (See N72-12861 03-31)

Avail. NTIS

The digital computer is the central control element in the Apollo control guidance and navigation system. The primary autopilots of the various spacecraft configurations of Apollo are implemented digitally in this general purpose processor. Successful control system design was made possible by capitalizing on the nature of digital processing and exploiting the attendant flexibility and nonlinear computability. After a brief description of the control system hardware, a detailed treatment of one of these autopilots, coasting flight attitude control is given.

Author

**N73-23881#** Advisory Group for Aerospace Research and Development, Paris (France)

**AUTOMATION IN MANNED AEROSPACE SYSTEMS**

Mar 1973 322 p refs. In ENGLISH and partly in FRENCH. Presented at 24th Tech. Meeting of the Avionics Panel of AGARD, Dayton, Ohio, 16-19 Oct 1972.

(AGARD-CP-114) Avail. NTIS HC \$18.25

Functional analyses of manned aerospace systems for the design of automatic avionics equipment are reported. Onboard computer capabilities to perform decision making functions, adaptive control, malfunction detection and compensation, real-time control are considered. For individual titles, see N73-23882 through N73-23905.

**N73-23882** Massachusetts Inst of Tech., Cambridge  
**MAN'S ROLE IN INTEGRATED CONTROL AND INFORMATION MANAGEMENT SYSTEMS**

J. L. Nevins and I. S. Johnson. In AGARD Automation in Manned Aerospace Systems Mar 1973 7 p refs (For availability see N73-23881 14-31)

An information processing and data management system is reported that relieves man's role in such tasks as pre-flight subsystem checkout and periodic system status checks. The prototype generalized display and command technique outlined features a pushplate interactive control scheme with graphic display in connection with an airborne computer.

G.G.

**N73-23883** Office National d'Etudes et de Recherches Aeronautiques, Paris (France)

**GENERAL GUIDELINE FOR THE DESIGN OF MANNED AEROSPACE VEHICLES**

Jean-Claude Wanner. In AGARD Automation in Manned Aerospace Systems Mar 1973 8 p refs (For availability see N73-23881 14-31)

The Franco-British airworthiness authorities reviewed the set of technical specifications required for Concorde in order to insure the safety of the missions of this new transport aircraft. In order to guide the definition of these new regulations, a theoretical method was developed for evaluating the probability of the missions of manned aerospace vehicles. This method is based on an investigation of the way of occurrence of accidents. It has been seen that an accident is due to a set of incidents which can be classified into only three different types. The study of each type of incident, the probability of occurrence which has to be reduced in order to increase the safety, is very useful to help the designer of a new project to choose between possible solutions, taking into account the reliability of the systems, the possible human errors and the flight conditions.

Author

**N73-23884** Grumman Aerospace Corp., Bethpage, NY  
**THE INFLUENCE OF COST AND TECHNICAL RISK ON THE DESIGN OF THE AVIONICS SYSTEM FOR THE SPACE SHUTTLE**

Howard T. Wright. In AGARD Automation in Manned Aerospace Systems Mar 1973 9 p (For availability see N73-23881 14-31)

The evolution of the Space Shuttle Program from its inception to the release of the request for proposal in April of 1972, has been influenced primarily by cost considerations. Various configurations were studied, and cost pre-flights were traded against developmental cost. These studies indicated operational costs between 4.5 million and 15.8 million dollars per flight. The baseline configuration was based on the best competition between development and operational cost considerations. The configuration selected was a small orbiter vehicle with an external hydrogen and oxygen tank and two solid rocket engines. This configuration results in operational cost per flight of approximately 11 million dollars.

Author

**N73-23885** Northrop Corp., Palos Verdes Peninsula, Calif.  
**AUTOMATIC ACQUISITION AND TRACKING METHODS EMPLOYED IN THE JOINT SERVICES IN-FLIGHT DATA TRANSMISSION SYSTEM (JIFDATS)**

T. N. Leiboff. In AGARD Automation in Manned Aerospace Systems Mar 1973 21 p (For availability see N73-23881 14-31)

JIFDATS is an all-weather, day-night, multi-sensor, in-flight data transmission system designed for use by all the military services. The normal operating mode for JIFDATS is automatic. Except for the usual checkout, servicing and maintenance activities in which personnel take a large part, the only need for personnel functions is to establish the proper conditions for system operation, turn on the system, and monitor the operation to

assure continuity of data transmission. In each case though, there is a manual back-up mode for bypassing the automatic features of acquisition and tracking. A scenario of a typical tactical reconnaissance mission is presented showing the various steps taken by the operator in the sensor aircraft, the operator in the relay aircraft, and personnel at the surface terminal during each phase of the mission. It is shown how the relay aircraft automatically acquires the sensor aircraft which is transmitting a low bandwidth signal on an omni-directional antenna, while it rotates its high-gain narrow beam directional antenna. The sensor aircraft locks on to the relay while the relay and ground terminals acquire and track. Author

**N73-23886** Consiglio Nazionale delle Ricerche, Genoa (Italy). **DETERMINATION OF AN OPTIMAL TRAJECTORY IN THE PRESENCE OF RISK**

A. Tiano, P. Dagnino, and M. Piattelli. In AGARD Automation in Manned Aerospace Systems. Mar. 1973. 19 p. refs. (For availability see N73-23881 14-31)

A controlled dynamic system is considered that displaces within an assigned space, where moving targets are contained. An optimal control sequence transfers the system from an initial point to a preset terminal point so that the optimal trajectory is the one which, complying with some safety constraints imposed by the targets, minimizes a given cost function. Assuming that the system may be supplied with periodical information about the motion of the targets, a numerical algorithm utilizing a dynamic programming procedure is determined. This procedure is applied to two practical problems: (1) Marine anticollision aided by computerized radar systems in the presence of  $N$  targets, and (2) determination of an optimal evasion strategy in the presence of cyclonic disturbances. Author

**N73-23887** North American Rockwell Corp., Downey, Calif. Space Div.

**SPACE STATION INFORMATION SYSTEM REQUIREMENTS: A CASE HISTORY OF MAN-MACHINE SYSTEM DEFINITION**

C. R. Gerber. In AGARD Automation in Manned Aerospace Systems. Mar. 1973. 8 p. (For availability see N73-23881 14-31)

The NASA space station definition studies incorporate a multiplicity of automated supporting functions to enhance the useful work capability of very few men. The SS information system is the means by which the men interface with all subsystems, space experiments, other vehicles, ground support facilities and personnel. It is therefore a driver in determining what program and mission objectives can be satisfied. The study resulted in the definition of an information subsystem consisting of a unique combination of multi-processing computation, internal data distribution via a digital data bus, crew interfacing via a set of multi-purpose display and control consoles, and external data distribution via a combination of VHF, S and K band RF links. Author

**N73-23888\*** International Business Machines Corp., Houston, Tex. Federal Systems Div.

**AUTOMATED TECHNIQUES FOR SPACECRAFT MONITORING**

H. Richard Segnar. In AGARD Automation in Manned Aerospace Systems. Feb. 1972. 12 p. refs. Sponsored by NASA. (For availability see N73-23881 14-31) CSCL 22B

The feasibility of implementing automated spacecraft monitoring depends on four factors: sufficient computer resources, suitable monitoring function definitions, adequate spacecraft data, and effective and economical test systems. The advantages of automated monitoring lie in the decision-making speed of the computer and the continuous monitoring coverage provided by an automated monitoring program. Use of these advantages introduces a new concept of spacecraft monitoring in which system specialists, ground based or onboard, freed from routine and tedious monitoring, could devote their expertise to unprogrammed or contingency situations. Author

**N73-23889** Saab Aircraft Co., Linköping (Sweden). Systems and Avionics Dept.

**SOME DEVELOPMENT TRENDS IN THE INTEGRATION OF ELECTRONIC SYSTEMS IN THE SWEDISH AIRCRAFT 37 VIGGEN**

Bengt Sjöebert. In AGARD Automation in Manned Aerospace Systems. Mar. 1973. 8 p. (For availability see N73-23881 14-31)

The Swedish 37 VIGGEN aircraft is being developed in several versions and the electronic systems of the attack version and the later fighter version are compared and some development trends are discussed. An increased role of the central computer is recognized as well as a trend towards digitalization of several subsystems. Author

**N73-23890** Aeritalia, Turin (Italy).

**MULTILOOP ATTITUDE CONTROL SYSTEM FOR A SATELLITE WITH FLEXIBLE BOOMS**

R. Di Lorenzo and E. De Bernardis. In AGARD Automation in Manned Aerospace Systems. Mar. 1973. 13 p. refs. (For availability see N73-23881 14-31)

A class of momentum exchange devices control configurations has been considered, namely that which provide a momentum quite larger along one body axis rather than along the other ones. The general equations of a satellite controlled in such a way have been used in order to provide a control system which is independent from the particular devices used; these equations have been modified in order to take into account that the satellite has a couple of flexible booms. A simple multiloop controller has been designed for such equations, and it is shown that to adapt it to each particular actuators configuration it is only necessary to design three very conventional inner control loops. Finally, a simulation of the full flexible systems has been made using FORTRAN 5, with reasonable numerical values of the satellite dynamic parameters, where it is shown that a controller designed considering rigid the whole satellite results either in instability or very degraded pointing accuracy. Author

**N73-23891\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

**OPTIMUM SPACEBORNE COMPUTER SYSTEM DESIGN BY SIMULATION**

T. Williams (Computer Sci. Corp., Huntsville, Ala.), H. Kerner, J. L. Weatherbee (Computer Sci. Corp., Huntsville, Ala.), D. S. Taylor (Computer Sci. Corp., Huntsville, Ala.), and B. Hodges. In AGARD Automation in Manned Aerospace Systems. Mar. 1973. 12 p. refs. (For availability see N73-23881 14-31) CSCL 09B

A deterministic simulator is described which models the Automatically Reconfigurable Modular Multiprocessor System (ARMMMS), a candidate computer system for future manned and unmanned space missions. Its use as a tool to study and determine the minimum computer system configuration necessary to satisfy the on-board computational requirements of a typical mission is presented. The paper describes how the computer system configuration is determined in order to satisfy the data processing demand of the various shuttle booster subsystems. The configuration which is developed as a result of studies with the simulator is optimal with respect to the efficient use of computer system resources. Author

**N73-23892** Consiglio Nazionale delle Ricerche, Pisa (Italy). Ist. di Elaborazione dell'Informazione.

**EXTENSION OF SIMULA 67 FOR PROCESS CONTROL**

Juliusz H. Kardasz. In AGARD Automation in Manned Aerospace Systems. Mar. 1973. 13 p. refs. (For availability see N73-23881 14-31)

**Copyright**

An extension of SIMULA 67 towards process control is reported. The extension is prepared with an idea of using it to control large systems of interconnected devices where the necessity for real time simulation arises in order to define a future behaviour of the system. This extension combines both characteristics of procedural and fill-in-the-blank (format oriented) languages. The programming requirements for process control

applications are discussed and a comparison is made between some algorithmic languages with respect to the degrees in which they meet these requirements. This discussion shows that SIMULA 67 requires the introduction of less new concepts than other languages in order to be extended for process control. These new concepts include first of all the interface with a process which is introduced by an external class to be implemented defined. A procedural language is used for constructing the body of the system, composed of procedures and classes.

Author

**N73-23893\*** National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Tex.  
**SYSTEMS PERFORMANCE MONITORING FOR ADVANCED MANNED SPACECRAFT**

T. V. Chambers. *In* AGARD Automation in Manned Aerospace Systems. Mar. 1973. 16 p. refs. (For availability see N73-23881 14-31)

CSCL 228

Optimum system mechanizations for advanced manned spacecraft are considered. Several studies have proposed automation of the onboard system management task, with functions such as system status monitoring, configuration management, and redundancy management being accomplished under computer control. An experimental system was used in the laboratory to investigate hardware and software requirements for accomplishing these onboard system management functions. A performance monitor system is proposed for the space shuttle. This system provides support to the flight crew in the management of all onboard systems but does not perform critical switching functions during the flight phase.

Author

**N73-23894** Selenia S.p.A., Rome (Italy)

**A GENERAL PURPOSE COMPUTER FOR SPACEBORNE APPLICATIONS**

S. Basso and R. Camberale. *In* AGARD Automation in Manned Aerospace Systems. Mar. 1973. 18 p. (For availability see N73-23881 14-31)

A modular expandable computer system is studied for a wide range of possible space missions. The main goals in designing the computer have been maximum flexibility and reliability, minimum weight and power consumption and growth capability to fit future mission requirements. The study resulted in a stored program, 16 bit, parallel machine, with microprogrammed control which allows full arithmetic and logic capability. Input/output includes program-controlled and direct-memory-access channels. The main points of trade-off for system design are presented and a description of the basic computer units at the functional block level is given.

Author

**N73-23895** Societe Nationale Industrielle Aerospatiale, Paris (France)

**INERTIALESS FLIGHT METHODS (PROCEDE DE SURVOL NON INERTIEL)**

P. J. Bignon, J. Langlois, and R. Berrier. *In* AGARD Automation in Manned Aerospace Systems. Mar. 1973. 19 p. *In* FRENCH (For availability see N73-23881 14-31)

An automatic inertialess flight control and guidance system is reported that determines aircraft position by precisely calculating actual flight course deviation for telemetric guidance correction. An onboard computer processes data from a platform containing directional and vertical gyroscopes, from an automatic pilot, and from an atmospheric pressure sensor.

Transl. by G. G.

**N73-23896** Royal Aircraft Establishment, Farnborough (England)  
**THE EXPERIMENTAL EVALUATION OF AUTOMATIC NAVIGATION SYSTEMS**

J. G. Carr. *In* AGARD Automation in Manned Aerospace Systems. Mar. 1973. 13 p. (For availability see N73-23881 14-31)

Certain aspects of automated avionics systems which are being examined in the RAE Comet exercise are described. The emphasis is on navigation systems and includes the work on digital computers and on-board digital communication techniques, software developments including the use of high level programming languages, and the use of computer controlled electronic displays. The laboratory work using simulated navigation sensor

inputs into an experimental system comprising a digital computer and electronic displays is described. A Comet 4 aircraft has been re-equipped as a flying laboratory for this work. The installation in the cabin of the aircraft and some of the current experimental investigations are described. The cockpit of the Comet has also been modified by the addition of experimental electronic displays to the second pilot's instrument panel.

Author

**N73-23897** Systems Control, Inc., Palo Alto, Calif.

**CURRENT STATUS OF MODELS FOR THE HUMAN OPERATOR AS A CONTROLLER AND DECISION MAKER IN MANNED AEROSPACE SYSTEMS**

A. V. Chatek and D. L. Kleinman. *In* AGARD Automation in Manned Aerospace Systems. Mar. 1973. 10 p. refs. (For availability see N73-23881 14-31)

Mathematical models of human decision processes and adaptive behavior have been proposed for specific control situations. Accepted techniques and models for analyzing and predicting human performance in complex multi-control and multi-display situations commonly found in aerospace systems are surveyed. The models have been developed or proposed for the related human functions of information processing, decision making and control. The relative advantages, disadvantages and limitations of each of the modeling schemes are discussed and prospects for re-examining all or part of the decision functions performed by human operators are considered, specific examples being in the automation of human failure detection and adaptation to sudden changes in the system operating conditions.

Author

**N73-23898** Royal Aircraft Establishment, Bedford (England)  
**MANUAL LANDING IN FOG**

R. R. Newbery. *In* AGARD Automation in Manned Aerospace Systems. Mar. 1973. 19 p. refs. (For availability see N73-23881 14-31)

The results of 18 fog flying sorties using a Category II operation terminated by a manual landing have been analyzed in an attempt to learn more about the pilot's capabilities in this environment. Measurements were made to correlate the pilot's decision making process with actual fog structures in real operation. A wide variety of fog structure and visual sequences are illustrated which demonstrate the lack of relationship between the visual segment at high decision heights, the height at which visual contact is first made and the runway visual range measurement. The pilots felt that Category II operation was straightforward provided that good quality approach performance, strict crew drills, accurate RVR reporting to give warning of shallow or changing fog conditions along the runway, were maintained.

Author

**N73-23899** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio

**MONTE CARLO SIMULATION OF DEGRADED MAN-MACHINE PERFORMANCE**

Gerald P. Chubb. *In* AGARD Automation in Manned Aerospace Systems. Mar. 1973. 11 p. refs. (For availability see N73-23881 14-31)

System vulnerability is a function of both human and hardware vulnerabilities to anticipated threat environments. The feasibility of considering the interaction of man and machine degradation under nuclear attack conditions has recently been demonstrated. It appears that the technique may be useful in identifying certain situations where automation may be particularly useful under these attack conditions, although the requirement is not obvious from analyses of system performance under nominal operating conditions. The approach taken appears generalizable to other degradation conditions, such as inflight malfunctions and conventional weapons battle damage. Given suggested changes in man-machine task sequencing, the model can aid in assessing how these changes may affect selected systems effectiveness measures. A number of refinements and extensions to the current capabilities of this model are envisioned and briefly discussed.

Author



**N73-23900** Marconi-Elliott Avionic Systems Ltd., Rochester (England)

#### DEVELOPMENTS IN AIRCRAFT DIGITAL SYSTEMS

R. Ruggles and E. M. Scott. In AGARD Automation in Manned Aerospace Systems Mar. 1973 11 p (For availability see N73-23881 14-31)

The effects of the relationship between user need and technological capability are considered for flight control as opposed to navigation and some physical characteristics of current digital autopilots are given. The functional division and integration of avionic subsystems are considered and it is concluded that integration in the form of loosely federated groups of related systems is preferred to the centralized computer complex in spite of its apparent conceptual simplicity. The concept of task oriented computers is discussed and the main parameters of some existing examples are given. Some details of the architecture, software and hardware for this type of computer are given. An example of the application to automatic flight control with a requirement for a fail operative capability is given and the problem of dealing with tolerances between operating lanes is briefly discussed. Author

**N73-23901** Hawker Siddeley Aviation, Ltd., Hatfield (England)  
**HUMAN FACTORS IN LOW WEATHER OPERATION OF TRANSPORT AIRCRAFT**

J. W. Wilson. In AGARD Automation in Manned Aerospace Systems Mar. 1973 5 p (For availability see N73-23881 14-31)

Practical experience gained during the manufacturer's flight development testing and airline in-service operation of a failure-survival Category 3 automatic landing system is reviewed for indications of the extent to which human factors have affected the design of the system and the techniques used by the airline in order to reach the very high safety levels that are necessary. The important factors influencing the complexity of the task are: (1) Provision of adequate monitoring devices located in the optimum area of each crew member's primary visual scan, to enable the pilot to keep ahead of the operation of the automatic control systems; (2) application of identical procedures for use in Category 1, 2 or 3 weather; (3) design of the system and development of procedures such that the maximum number of manual and automatic functions that require action, checking or monitoring can be completed before the final stage of the approach to land; and (4) the decision to land should be made as low as possible, compatible with a go-around performance which will not normally result in touchdown. Author

**N73-23902** Air Force Systems Command, Wright-Patterson AFB, Ohio. Airborne Computer Engineering Branch  
**AVIONIC SYSTEMS INTEGRATION USING DIGITAL COMPUTERS**

Erwin C. Gangl. In AGARD Automation in Manned Aerospace Systems Mar. 1973 5 p (For availability see N73-23881 14-31)

Present weapon systems use a multiplicity of signal formats and transmission techniques for information transfer within an integrated avionics system. The implementation of a serial digital data bus as the primary means of functionally communicating and interconnecting the various equipments is described. If a system is logically partitioned to the data it supplies, requires or processes, then with a flexibly designed digital data bus and standard interfaces, it can easily be integrated through the computer software. Modification or redesign of the multiplexed data bus concept is a matter of reconfiguration of the building blocks, adding and deleting as required and then changing the software to reintegrate the new configuration, saving the costly rewiring and redesigning of the computer converter box. The computer is now a separate line replaceable unit, not subject to obsolescence due to systems modifications. Author

D. A. Lloyd. In AGARD Automation in Manned Aerospace Systems Mar. 1973 31 p refs (For availability see N73-23881 14-31)

The statistics of the output state variables of automatic aerospace systems are of considerable interest and of wide application, particularly in the case of manned systems. The paper shows that the exponential probability distribution can be used as an approximation to the distributions of the output state variables of practical aerospace systems for a wide range of practical situations. The use of the exponential distribution as a practical mathematical tool is suggested in the assessment of some of the performance statistics of aerospace systems, both for preliminary calculations and for final calculations involving the extrapolation of test results. Author

**N73-23904\*** National Aeronautics and Space Administration, Washington, DC  
**POTENTIAL TELEOPERATOR APPLICATIONS IN MANNED AEROSPACE SYSTEMS**

Edwin G. Johnson. In AGARD Automation in Manned Aerospace Systems Mar. 1973 4 p refs (For availability see N73-23881 14-31)

#### CSSL 05H

The trend of teleoperator development is toward digital computer controlled systems which utilize local sensor-computer-actuator loops to avoid obstacles and to sense manipulator grip-and-slip. The potential applications of advanced teleoperator technology to manned aerospace systems include long manipulator booms to be mounted on the shuttle. These can transfer cargo from the space shuttle and can acquire and retrieve objects in space. Free-flying teleoperators capable of acquiring, inspecting, repairing or refurbishing satellites in orbit are another space application. Another potential application of teleoperator technology is the concept of using an anthropomorphic teleoperator in lieu of man to control aircraft or spacecraft normally controlled by a human pilot. Author

**N73-23905** Boeing Co., Seattle, Wash.  
**MAN-MACHINE CONSIDERATIONS IN THE DEVELOPMENT OF A COCKPIT FOR AN ADVANCED TACTICAL FIGHTER**

S. Joel Premiselaar and D. E. Frearson (AFFDL). In AGARD Automation in Manned Aerospace Systems Mar. 1973 20 p (For availability see N73-23881 14-31)

A revolutionary cockpit concept for a 1975-85 one-man, multi-mission fighter aircraft completed an initial simulation phase recently. The design goal of this concept is to achieve a one-man workload level by presenting the pilot only the information necessary for the particular mission segment he is performing, and yet provide maximum flexibility in terms of pilot options. Key elements of the cockpit design are: Multiple, time-shared electronic displays; keyboard and voice command computer input devices; wrap-around cockpit arrangement for ease of access to the control-display devices; an integrated total energy command; and a system of dependent automation that permits reduced pilot workload during anomalies. The simulator provides a one-of-a-kind capability for examination of the flight deck design issues involved in tailoring the power and flexibility of the computer to the capabilities and limitations of the human pilot in the performance of his mission. Author

**N73-23903** Smiths Industries, Ltd., Cheltenham (England)  
Aviation Div

#### THE EXPONENTIAL PROBABILITY DISTRIBUTION AND ITS USE IN ASSESSING THE PERFORMANCE STATISTICS OF AEROSPACE SYSTEMS

## 32 STRUCTURAL MECHANICS

Includes structural element design and weight analysis fatigue thermal stress impact phenomena vibration flutter inflatable structures and structural tests For related information see also 17 Materials Metallic and 18 Materials Nonmetallic

**N71-20128#** Advisory Group for Aerospace Research and Development Paris (France)

### STRUCTURAL DESIGN APPLICATIONS OF MATHEMATICAL PROGRAMMING TECHNIQUES

G G Pope and L A Schmit eds Feb 1971 203 p refs (AGARD-AG-149-71 AGARDOGRAPH 149) Avail NTIS

#### CONTENTS

- 1 INTRODUCTION AND BASIC CONCEPTS L A Schmit and G G Pope p 2 13 refs (See N71 20129 09 32)
- 2 A BASIS FOR ASSESSING THE STATE OF THE ART L A Schmit p 14 29 refs (See N71 20130 09 32)
- 3 CLASSICAL OPTIMIZATION THEORY RELEVANT TO THE DESIGN OF AEROSPACE STRUCTURES G G Pope p 30 33 refs (See N71 20131 09 32)
- 4 LITERATURE REVIEW AND ASSESSMENT OF THE PRESENT POSITION L A Schmit p 34 45 refs (See N71 20132 09 32)
- 5 SEQUENCE OF LINEAR PROGRAMS G G Pope p 46 54 refs (See N71 20133 09 08)
- 6 UNCONSTRAINED MINIMIZATION APPROACHES TO CONSTRAINED PROBLEMS R L Fox p 55 78 refs (See N71 20134 09 19)
- 7 FEASIBLE DIRECTION METHODS J S Kowalik p 79 93 refs (See N71 20135 09 19)
- 8 COMPUTER PROGRAMS FOR THE OPTIMUM DESIGN OF COMPLEX ELASTIC STRUCTURES G G Pope p 96 101 refs (See N71 20136 09 08)
- 9 SPECIAL PURPOSE APPLICATIONS L A Schmit p 102 123 refs (See N71 20137 09 19)
- 10 OPTIMIZATION OF STRUCTURES WITH RELIABILITY CONSTRAINTS F Moses p 126 143 refs (See N71 20138 09 32)
- 11 OPTIMIZATION UNDER AEROELASTIC CONSTRAINTS H Ashley S C McIntosh Jr and W H Weatherhill p 144 173 refs (See N71 20139 09 32)
- 12 OPTIMIZATION TECHNIQUES IN AIRCRAFT CONFIGURATION DESIGN B Silver and H Ashley p 174 194 refs (See N71 20140 09 32)

**N71-20129#** Advisory Group for Aerospace Research and Development Paris (France)

### INTRODUCTION AND BASIC CONCEPTS

L A Schmit and G G Pope In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 2 13 refs (See N71 20128 09 32) Avail NTIS

The application of mathematical programming methods to aerospace structural design is discussed. The fundamental ideas are illustrated by considering the elementary examples of a simply supported column and a two bar truss. The traditional approach to least weight design of aircraft structures is stated to be formulating the optimization problem in terms of equations and a variation is the reduction of the objective function to one of a single variable. Terminology used in mathematical programming is defined and the main features in applying the techniques to structural design are outlined. Mathematical programming techniques applied to materials selection is usually characterized by a discrete set of available materials, even for composite materials. N E N

**N71-20130#** Advisory Group for Aerospace Research and Development Paris (France)

### A BASIS FOR ASSESSING THE STATE OF THE ART

L A Schmit In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 14 29 refs (See N71 20128 09 32)

Avail NTIS

The design philosophy in combining computer oriented structural analysis with mathematical programming methods is described. One approach to the problem is to design the structure so that initial yielding under service load conditions is avoided, and another is to design so as to prevent collapse under service load conditions. Design variables and weight minimization as the objective function are described. Formulations are discussed and include sequence of linear programs, sequence of unconstrained minimizations, basic nonlinear programming and classical formulation of the inequality constrained minimization problem. N E N

**N71-20131#** Advisory Group for Aerospace Research and Development Paris (France)

### CLASSICAL OPTIMIZATION THEORY RELEVANT TO THE DESIGN OF AEROSPACE STRUCTURE

G G Pope In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 30 33 refs (See N71 20128 09 32)

Copyright Avail NTIS

Design optimization of aerospace structures which must behave elastically under service conditions is discussed. The classical theorem which is applicable directly to the least weight design of highly idealized frameworks is emphasized. It is assumed that the structure is fabricated from an elastic perfectly plastic material and the basic theory for single and multiple load conditions is given. The optimum layout of least weight elastic frameworks and general properties are described. N E N

**N71-20132#** Advisory Group for Aerospace Research and Development Paris (France)

### LITERATURE REVIEW AND ASSESSMENT OF THE PRESENT POSITION

L A Schmit In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 34 45 refs (See N71 20128 09 32)

Avail NTIS

A selective review of articles on mathematical programming applications to structural design optimization limited to finite problems is presented. An effort is made to trace the development of programming applications and papers thought to have strongly influenced this development are discussed. Current and future trends are also described and brief reviews are given on structural optimization in the dynamic response regime and reliability based structural optimization. N E N

**N71-20133#** Advisory Group for Aerospace Research and Development Paris (France)

### SEQUENCE OF LINEAR PROGRAMS

G G Pope In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 46 54 refs (See N71 20128 09 32)

Copyright Avail NTIS

The reduction of nonlinear programming problems to a sequence of linear programming problems is discussed. Important properties of linear programming problems and methods of their solution are described. In nonlinear programming problems considered first are those in which all constraints are expressed as inequalities and in which only two variables are involved. Methods of reducing the nonlinear problems are outlined. The simplest approach linearizes the constraints and merit function in the neighborhood of an arbitrary point. The cutting plane method

employs the property that linearized constraints in convex problems necessarily lie entirely outside the feasible region. The move limit method makes use of artificial limits on the variation of the design variables in a typical linearized computation. In all of these methods, the coefficients of the design variables in the objective function of the primal problem are nearly always all positive.

N E N

**N71-20134#** Advisory Group for Aerospace Research and Development Paris (France)

#### UNCONSTRAINED MINIMIZATION APPROACHES TO CONSTRAINED PROBLEMS

R L Fox *In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 55-78 refs (See N71-20128 09 32)*

Avail NTIS

Several unconstrained minimization methods are discussed and their advantages and disadvantages are presented. The basic idea of these methods is to convert the constrained problem, with its objective function and equality and inequality constraints, into a problem in which some new function is minimized without regard for constraints. The solution to the original problem is developed through a sequence of unconstrained minimizations. The reliability of the algorithms, their sequential nature, and the straightforward formulation and implementation of these methods are described. Formulations employing interior penalty functions are discussed in order to apply the unconstrained minimization methods to the solution of the constrained problem. Formulations employing exterior penalty functions, and penalty functions for equality constraints are also mentioned.

N E N

**N71-20135#** Advisory Group for Aerospace Research and Development Paris (France)

#### FEASIBLE DIRECTION METHODS

J S Kowalik *In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 79-93 refs (See N71-20128 09 32)*

Avail NTIS

Algorithms for solving a general nonlinear programming problem, and which have proved to be successful and applicable to structural optimization problems are discussed. The advantages and disadvantages of the methods are compared from theoretical and computational viewpoints. Zoutendijk's usable feasible directions method efficiently reduces the problem to a sequence of linear programming problems, is finite for quadratic programming problems, and can handle nonconvex problems. A modified feasible directions method utilizes some ideas of the cutting plane method. Rosen's gradient projection method uses projections of the objective function gradient into the manifold defined by currently active constraints. The method works with vectors which are feasible and usable and replaces linear optimization subproblems with matrix inversion schemes. Gellatly's optimum vector method determines the direction of search from a set of simultaneous linear equations which can be solved by the stable Choleski decomposition method.

N E N

**N71-20136#** Advisory Group for Aerospace Research and Development Paris (France)

#### COMPUTER PROGRAMS FOR THE OPTIMUM DESIGN OF COMPLEX ELASTIC STRUCTURES

G Pope *In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 96-101 refs (See N71-20128 09 32)*

Copyright Avail NTIS

Computer programs developed for the optimum design of linearized aerospace structures of arbitrary geometry, including optimization algorithms and sequences for finite element analysis are described. These programs are concerned mainly with the choice of member cross sectional areas and thicknesses, but some include

facilities which permit the lengths and spacings of members to be varied within a prescribed topology. Rigorous optimization procedures are emphasized. Computer programs developed to apply mathematical programming techniques to the least weight design of complex stress skin structures and major subsequent contribution are discussed. Application of iterative procedures for the generation of fully stressed designs is also described.

Author

**N71-20137#** Advisory Group for Aerospace Research and Development Paris (France)

#### SPECIAL PURPOSE APPLICATIONS

L A Schmit *In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 102-123 refs (See N71-20128 09 32)*

Avail NTIS

A few examples of mathematical programming applications to specific structural design problems are described. The examples discussed point up the important role structural optimization can play in evaluating alternative design concepts and materials based upon a comparison of optimum. The stiffened cylindrical shell optimization capability is reviewed in some detail. The extension of this capability to shells with slight meridional curvature is briefly discussed and two recently reported special purpose applications to fiber composite structures are noted. Application of an integrated penalty function approach to the optimum design of an ablating composite type heat shield is described.

Author

**N71-20138#** Advisory Group for Aerospace Research and Development Paris (France)

#### OPTIMIZATION OF STRUCTURES WITH RELIABILITY CONSTRAINTS

F Moses *In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 126-143 refs (See N71-20128 09 32)*

(Grants NSF GK 74, NSF GK-1871)

Avail NTIS

The relationship between optimum design of structure as it is now formulated in almost classical terms and reliability or safety of structures is studied. The kinds of structures for which reliability or failure probability can reasonably be analyzed and have been presented particularly in a redesign or optimization procedure are discussed. As the topic concerns safety in a probabilistic framework some attention is given to relevant questions of probability sensitivity, failure costs, limited empirical information, analysis errors, and safety philosophy. Several examples of optimization with reliability or failure probability constraints are presented.

Author

**N71-20139#** Advisory Group for Aerospace Research and Development Paris (France)

#### OPTIMIZATION UNDER AEROELASTIC CONSTRAINTS

H Ashley, S C McIntosh Jr, and W H Weatherhill *In its Structural Design Appl of Mathematical Programming Tech Feb 1971 p 144-173 refs. Sponsored by NASA and the AF (See N71-20128 09 32)*

(NASA CR-117198) Avail NTIS CSCL 20K

Two major lines of development in the optimization of aeroelastic constraints for high performance aircraft design are discussed. The optimization of problems with one dimensional space variable can be identified as a variational problem and reduced to systems of first order ordinary differential equations. Discretization by assumed-mode and finite element methods are also described and the control variables are replaced with a finite vector of  $n$  adjustable element properties. Minimization of the chosen merit function amounts to a search of  $n$  vectorspace. Mathematical discussions of examples are given for each method and the importance of each method in future development is indicated.

N E N

**N71-20140#** Advisory Group for Aerospace Research and Development, Paris (France)

**OPTIMIZATION TECHNIQUES IN AIRCRAFT CONFIGURATION DESIGN**

B. Silver and H. Ashley. In *Structural Design Appl. of Mathematical Programming Tech.* Feb. 1971. p. 174-194. refs. (See N71-20128, 09-32)

Avail. NTIS

Parametric analysis and automated search methods for preliminary design optimization are compared, and methods of optimization that go beyond parametric analysis are investigated. Indirect methods, such as the calculus of variations, are mentioned. Direct methods of optimization are discussed including selection of design variables, constraint formulation, methods with and without derivatives, one-dimensional search methods, and convergence criteria. The indirect methods solve auxiliary problems, while the direct methods adopt a hill-climbing strategy on the objective function directly. Operational results of direct search methods are given, and the field of man-computer interactive design is briefly described. NEN

**N71-25449#** Advisory Group for Aerospace Research and Development, Paris (France)

**COOPERATIVE CREEP TESTING PROGRAM**

D. Coussouradis (Centre Natl. de Rech. Met.) and D. K. Fauschou (Dept. of Energy, Mines and Resources). Mar. 1971. 100 p. refs. (AGARD-R-581-71). Avail. NTIS

The Advisory Group for Aerospace Research and Development (AGARD) initiated an interlaboratory study of high temperature creep testing facilities and techniques. The program utilized factorial design and analysis. Nimonic 105 was tested at 900°C by eighteen voluntary laboratories. The results have permitted statistical evaluation of intra and interlaboratory variability and the significance of some testing and material variables which affect creep results. Author

**N72-13982#** Advisory Group for Aerospace Research and Development, Paris (France)

**THE ELEMENTS OF FRACTOGRAPHY**

D. A. Ryder (Manchester Univ.). Nov. 1971. 196 p. refs. (AGARD-AG-155-71; AGARDograph-155). Avail. NTIS

This monograph is intended to serve as an introduction to 'Fractography' which may be defined as the examination of fracture surfaces at magnifications ranging from  $\times 1$  to  $\times 100,000$ . The terminology and current ideas on fracture are introduced in an elementary account of those factors that control the mechanical properties of engineering materials. Fracture is discussed in general terms and the instruments available for fracture surface analysis are considered. The experimental and operational techniques needed in fractography are discussed with a variety of factors, especially artefacts in replicas prepared for transmission electron microscopy, that can influence the interpretation of experimental results. The application of fractography to the investigation of service failures and the use of the technique in fracture research are described. Author

**N72-21900#** Advisory Group for Aerospace Research and Development, Paris (France)

**SPECIALISTS MEETING ON STRESS CORROSION TESTING METHODS**

Jan. 1972. 332 p. refs. Presented at Struct. and Mater. Panel 33d Meeting, Brussels, 5-8 Oct. 1971. (AGARD-CP-98). Avail. NTIS. HC \$6.00/MF \$0.95

The basic objectives of the Specialists Meeting were to discuss: (1) the utility and significance of stress corrosion cracking data to current engineering and design practices; (2) the progress being made NATO countries toward standardization of test techniques for stress corrosion cracking; and (3) those test methods which might be recommended as standard techniques in the immediate future. Also included are the types and quality of data which are useful in design analysis, the

attitudes and activities of various corrosion and fracture committees in the U.S. and Europe toward standardization techniques, and summaries of stress corrosion cracking and test equipment used to measure corrosion in various materials, aircraft structures, and space shuttle designs. For individual titles, see N72-21901 through N72-21931.

**N72-21901#** Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.

**ENGINEERING UTILITY AND SIGNIFICANCE OF STRESS CORROSION CRACKING DATA**

W. E. Anderson. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 23 p. refs. (See N72-21900, 12-32)

Avail. NTIS. HC \$6.00/MF \$0.95

Some historical experiences with cracking and fracture problems are explored to indicate the significance of corrosion acting concomitantly with stress. These experiences suggest that cracks develop either in 'open' or 'closed' areas; and, either at regions accessible to the ambient environment and direct view, or at regions which are structurally hidden. Special attention was given to aircraft structures and various other materials. Data cover specimen configurations, methods suitable for low cost testing of specimens, and estimates of service life under loading and environmental conditions. A definition of stress corrosion is included. Author

**N72-21902#** Reynolds Metals Co., Richmond, Va. Metallurgical Research Div.

**PROGRESS TOWARD STANDARDIZATION OF SCC TEST TECHNIQUES BY THE AMERICAN SOCIETY FOR TESTING AND MATERIALS**

H. Lee Craig, Jr. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 10 p. (See N72-21900, 12-32)

Avail. NTIS. HC \$6.00/MF \$0.95

The work of a subcommittee on test standards for stress corrosion of metals and other materials is presented. The committee covers: (1) smooth specimens and test rig; (2) test environments and specific material tests; (3) corrosion fatigue; and (4) precracked specimens. Author

**N72-21903#** Aluminum Co. of America, Pittsburgh, Pa. Chemical Metallurgy Div.

**PROGRESS TOWARD STANDARDIZATION OF SCC TEST TECHNIQUES BY THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS AND THE ALUMINUM ASSOCIATION**

Donald O. Sprowls. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 20 p. (See N72-21900, 12-32)

Avail. NTIS. HC \$6.00/MF \$0.95

The stress corrosion testing of high strength, heat treatable aluminum alloys is discussed. Three tempers of alloy 7075 were laboratory tested for the purposes of: (1) comparing three types of smooth test specimens; (2) ascertaining the uniformity of test results that can be expected with a closely controlled procedure for the 3.5% NaCl alternate immersion test; (3) evaluating other corrosive agents that do not cause severe pitting of these alloys; and (4) relating the SCC (stress corrosion cracking) performance in these laboratory tests with that in outdoor atmospheres. Author

**N72-21904#** Newcastle upon Tyne Univ. (England). Dept. of Metallurgy

**STRESS CORROSION TEST METHODS: THE EUROPEAN FEDERATION OF CORROSION CONTRIBUTION**

R. N. Parkins. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 7 p. (See N72-21900, 12-32)

Avail. NTIS. HC \$6.00/MF \$0.95

A précis is given of the major points on stress corrosion test methods as compiled by the European Federation of Corrosion Working Party. The data points to some of the

problems associated with the various methods of testing, such as the extensive use of time to failure as a parameter that measures susceptibility and the apparently poor reproducibility of threshold stress intensity values for stress corrosion cracking. On the environmental side of testing, the dangers in the use of standard solutions are indicated and the necessity in simulating service failures, of precisely reproducing the composition of the environment and the relevant electrode potential are shown.

Author

**N72-21906\*** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.

**SOME IMPORTANT CONSIDERATIONS IN THE DEVELOPMENT OF STRESS CORROSION CRACKING TEST METHODS**

R. P. Wei (Lahigh Univ.), S. R. Novak (US Steel Corp., Monroeville, Pa.), and D. P. Williams. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 10 p. refs. (See N72-21900 12-32)  
(Contract N00014-68-A-0514)

(NASA-TM-X-68303) Avail. NTIS CSCL 148

The need for recognizing certain potentially serious problems in the development of standard test methods for stress corrosion cracking studies is discussed. The importance of recognizing and satisfying the basic assumptions of the linear-elastic fracture mechanics analysis in experimentation is re-emphasized. The effects of nonsteady-state crack growth, including incubation, must be taken into account in determining the crack growth kinetics. These effects and the influences of steady-state crack growth kinetics, as well as a host of geometrical, material and environmental variables, must be considered in arriving at suitable criteria for KISCC (apparent threshold for stress corrosion cracking) determinations.

Author

**N72-21908\*** British Steel Corp., Sheffield (England). **CURRENT PROGRESS IN THE COLLABORATIVE TESTING PROGRAMME OF THE STRESS CORROSION CRACKING (FRACTURE MECHANICS) WORKING GROUP**

A. H. Prest and P. McIntyre. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 17 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00 MF \$0.95

A preliminary analysis is presented of the initial results of the Collaborative Testing Program of the Stress Corrosion Cracking (Fracture Mechanics) Working Group of the FSC Corporate Laboratories. In this analysis the results are interpreted in terms of the influences of specimen geometry, maximum fatigue precracking stress intensity, test temperature and laboratory error. It is concluded that the only significant errors can be attributed to differences in the calibration and accuracy of testing equipment between the participating laboratories and to failure to adhere to the recommended testing procedure which is found to be satisfactory for the material and environment which were used.

Author

**N72-21907\*** Leeds Univ. (England). Dept. of Metallurgy. **THE SCIENCE COMMITTEE CONFERENCE ON THE THEORY OF STRESS CORROSION CRACKING OF ALLOYS**

J. C. Scully. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 6 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00 MF \$0.95

The general aspects of stress corrosion cracking, as well as individual alloy systems are considered. Of particular interest (1) testing methods were (1) repassivation and (2) measurements of crack velocity. These are discussed and their relevance to testing methods is emphasized. Comparison between different alloys or of different heat treatments of an alloy can only be made if the relationship between mechanical, metallurgical and electrochemical variables on crack propagation kinetics is fully determined.

Author

**N72-21908\*** Tyco Labs., Inc., Waltham, Mass. Materials Science Dept.

**MEASURING THE DEGREE OF CONJOINT ACTION BETWEEN STRESS AND CORROSION IN STRESS CORROSION**

Franklin H. Cooks. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 7 p. (See N72-21900 12-32)

Avail. NTIS HC \$6.00 MF \$0.95

A stress corrosion testing method which allows a quantitative separation between the effects of stress and those of corrosion in causing stress corrosion damage is described. This test involves the measurement of the reduction in subsequent stress corrosion life which is brought about by initially exposing the sample to the corrosive environment without any stress being applied (precorrosion). If a given alloy is susceptible only to the combination of stress and corrosion (true stress corrosion), then such a preexposure would not be expected to greatly reduce its subsequent stress corrosion lifetime. In, however, a corrosion process that is not accelerated by stress is required to initiate the failure process, then such preexposure without applied stress may be found to be almost as damaging as an equal amount of exposure carried out under stress. A stress corrosion index (SCI) is defined which quantitatively measures these effects. Data obtained by this method are presented for a high strength aluminum alloy (7075) tested in buffered NaCl solution. For specimens of this alloy having a machined surface finish, 80% of the time required to produce failure in normal stress corrosion tests is found to be due to a process which is not accelerated by applied stress. An explanation for this behavior is offered in terms of the existence of a highly deformed surface layer within which any well defined grain boundaries have been destroyed. This surface layer must be penetrated by pitting before a true stress corrosion process can begin.

Author

**N72-21909\*** Bell Aerospace Co., Buffalo, N.Y. **THE pH AND POTENTIAL MEASUREMENTS DURING STRESS CORROSION OF ALUMINUM ALLOYS**

J. A. Davis. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 15 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00 MF \$0.95

A technique was described for using small tip diameter microelectrodes to study the stress corrosion behavior of various aluminum alloys exposed to chloride environments. Several general observations concerning the stress corrosion behavior of aluminum alloys were made: (1) propagation of a stress corrosion crack is always accompanied by a decrease in pH near the crack tip; (2) increasing the stress intensity to above K<sub>ISCC</sub> (threshold stress intensity for stress corrosion cracking) results in a rapid active shift in corrosion potential; and (3) as cracks progress, the corrosion potential slowly shifts in the active direction. A general mechanism for stress corrosion based on these observations is that crack propagation occurs by active path dissolution with a minimum applied stress required to rupture the passive film and initiate crack propagation.

Author

**N72-21910\*** Welding Inst., Cambridge (England). **STRESS CORROSION TESTING OF WELDED JOINTS**

T. G. Gough. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan. 1972. 7 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00 MF \$0.95

The techniques used for assessing the stress corrosion behavior of welded joints are outlined. Special attention was given to quantitative assessment of the susceptibility of weldments in the range of transformable steels, the cause of failure and the effects of material composition and microstructure. Several conclusions of the results are given.

Author

**N72-21911#** Department of Energy, Mines and Resources  
Ottawa (Ontario) Corrosion Section  
**SCREENING TESTS OF SUSCEPTIBILITY TO STRESS  
CORROSION CRACKING**

G. J. Riefler and J. G. Garrison. In AGARD Specialists Meeting  
on Stress Corrosion Testing Methods Jan 1972 9 p refs  
(See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

For five high strength alloys susceptibilities to the propagation of stress corrosion cracking (SCC) were assessed. Using 3.5% NaCl solution as the medium, both parent and weld metals were investigated. Specimens were studied under freely corroding conditions, and also cathodically protected at the potentials given by cadmium and by zinc sacrificial anodes. The cantilever test was used; the test specimens, cut from 1/2- and 3/4-in plates, were bars notched on both the sides and the top. Prior to tests a precrack was always produced at the base of the top notch by fatiguing in air. The equipment was designed so that specimens loaded as cantilevers, were broken by means of a steadily rising load. This was applied by dripping water at a constant rate into a container suspended from the end of the cantilever beam. Results were reported in terms of the nominal stress intensities  $K^*$  at fracture. While, strictly speaking, only of qualitative significance, reproducibility of the  $K^*$  values was good and the effects of metallurgical and environmental factors could be readily estimated. Author

**N72-21912#** Naval Air Development Center, Johnsville, Pa.  
**STRESS CORROSION TESTING OF TITANIUM ALLOYS**  
S. J. Ketcham, C. E. Neu, and S. Goldberg (Naval Air Sys  
Command). In AGARD Specialists Meeting on Stress Corrosion  
Testing Methods Jan 1972 8 p refs (See N72-21900  
12-32)

Avail NTIS HC \$6.00 MF \$0.95

Results are presented of two studies: (1) effect of grain flow orientation on stress corrosion susceptibility of two titanium alloys and (2) stress corrosion tests of titanium electron beam weldments. Emphasis is on test specimens used and on some properties of titanium alloys which have to be considered when conducting stress corrosion tests. Author

**N72-21913#** British Steel Corp., Sheffield (England)  
**FACTORS INFLUENCING THRESHOLD STRESS INTENSITY  
VALUES AND CRACK PROPAGATION RATES DURING  
STRESS CORROSION CRACKING TESTS OF HIGH  
STRENGTH STEELS**

A. H. Priest and P. McIntyre. In AGARD Specialists Meeting on  
Stress Corrosion Testing Methods Jan 1972 12 p refs (See  
N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

Threshold stress intensity values for stress corrosion cracking (KISCC) of a number of steels was shown to be related to the formation of a continuous stretch zone at the fatigue crack tip. Both KISCC and crack propagation rate (KIC) values are influenced by the yield strength and inclusion density of the steel. The relative values of KISCC determined by arrest and initiation methods and stress corrosion crack growth rates are influenced by the effectiveness of stress corrosion cracks as stress concentrators since intergranular cracks become progressively more blunt as they propagate while the reverse can be true of transgranular cracks. Observed stress corrosion crack propagation rates are also influenced by the failure to attain equilibrium in specimens of conventional length and by the presence of crack curvature and crack branching where these occur. Author

**N72-21914#** Westinghouse Research Labs., Pittsburgh, Pa.  
Mechanics Dept.  
**AN APPARATUS FOR STRESS CORROSION TESTING  
WITH LARGE PRECRACKED WOL SPECIMENS**

L. J. Cecchini and W. G. Clark Jr. In AGARD Specialists  
Meeting on Stress Corrosion Testing Methods Jan 1972 9 p

refs (See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

A laboratory test unit designed for KISCC (value of plane-strain stress intensity factor below which an existing crack will not grow due to stress corrosion) and stress corrosion crack growth rate testing with large precracked WOL (wedge-opening loading) specimens is described. The apparatus involves the use of a unique hydraulic loading arrangement which provides a convenient means of generating the relatively high loads required for stress corrosion testing with large WOL specimens. Additional features of the test unit include the ability to continuously monitor crack growth during the test and also the ability to test in an enclosed environment at various temperatures and pressures. Author

**N72-21915#** Frankford Arsenal, Philadelphia, Pa.  
**TENSILE LIGAMENT INSTABILITY AND THE GROWTH OF  
STRESS CORROSION CRACKS IN A HOMOGENEOUS  
Xn-Mg-Cu ALUMINUM ALLOY**

Joseph H. Mulhern. In AGARD Specialists Meeting on Stress  
Corrosion Testing Methods Jan 1972 7 p refs (See  
N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

The application of the Krafft tensile ligament model to the stress corrosion phenomenon of a homogeneous Zn-Mg-Cu aluminum alloy is discussed. The variant in the series was the degree of homogeneity of the microstructure. According to the model, the largest variation in the susceptibility to stress corrosion crack propagation was attributable to an increase in the rate of surface chemical attack around the circumference of the ligaments. Author

**N72-21916#** North American Rockwell Corp., Thousand Oaks,  
Calif. Science Center  
**AN ULTRA-HIGH VACUUM SYSTEM FOR DETERMINING  
THE EFFECTS OF GASEOUS ENVIRONMENTS ON  
FATIGUE AND FRACTURE PROPERTIES OF METALS**

H. L. Marcus and P. J. Stocker. In AGARD Specialists Meeting  
on Stress Corrosion Testing Methods Jan 1972 8 p refs (See  
N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

A high vacuum, 10 to the minus 10th power torr, all-metal system is described in which crack growth behavior of metals under static and dynamic loading can be studied. Provisions are made to introduce clean gases to the system, such as hydrogen and oxygen to study their effects on the crack growth phenomena. Crack growth results are presented for Ni-200 exposed to low pressures of hydrogen gas in the 10 to the minus 8th power to 150 torr pressure range. Author

**N72-21917#** Ohio State Univ., Columbus Dept. of Metallurgical  
Engineering  
**ACOUSTIC EMISSIONS AND SLOW CRACK GROWTH IN  
HIGH STRENGTH STEEL**

R. W. Staehle and G. E. Kerns. In AGARD Specialists Meeting  
on Stress Corrosion Testing Methods Jan 1972 12 p refs  
(See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

Acoustic emission techniques were used to study stress corrosion cracking in high strength material. Pre fatigue cracked single cantilever specimens were loaded and exposed to gaseous and aqueous environments. Acoustic emission signal shape and total resonance counts were recorded for specimens of different strength levels tested in different environments. Also, the phenomenon of wave reflection was reduced in order to examine the frequency content and energy of the emission. The results show that a higher strength level produces more acoustic activity regardless of environment. Also, the generated stress wave is of a high frequency and low energy nature. Author

**N72-21918#** Fiat SpA, Turin (Italy). Lab. Auto. Avio.  
**A CONTRIBUTION TO STRESS CORROSION TESTING OF ALUMINUM ALLOYS**

Giovanni Bollani. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan 1972. 13 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00; MF \$0.95

The results of an extensive investigation for the improvement of the stress corrosion testing methods on high strength Al alloys are briefly outlined. For the evaluation of the crack initiation period under different stress conditions, two smooth specimens of original design are recommended. For the measure of the crack propagation rate, the DCB (Double Cantilever beam) pre-cracked specimen was found effective. Author

**N72-21919#** Naval Ship Research and Development Center, Annapolis, Md. Corrosion Branch

**INFLUENCE OF TEST METHOD ON STRESS CORROSION BEHAVIOR OF ALUMINUM ALLOYS IN SEA WATER**

George J. Danek. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan 1972. 11 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00; MF \$0.95

Highlights are presented of recent investigations on sea water stress corrosion behavior of high strength aluminum alloys. Rolled 7000-series plate was used to show a significant influence of specimen orientation on sea water stress corrosion response. The results suggested that tests in the short transverse direction are essential in ascertaining stress corrosion behavior of high strength aluminum alloys in either smooth or precracked specimens. Based on these results a number of high strength hand forgings, representing the 2000-, 6000-, and 7000-series were tested as bent beam and precracked cantilever specimens taken in the short transverse direction. Inconsistencies are observed when the sea water stress corrosion results from precracked cantilever specimens are compared to those from smooth specimens. The results indicate that each of the two techniques provides important information, and both methods should be used in assessing the sea water stress corrosion behavior of high strength aluminum alloys. Author

**N72-21920#** Aluminum Co. of America, Pittsburgh, Pa. Chemical Metallurgy Div

**DISCUSSION OF PAPER, INFLUENCE OF TEST METHOD ON STRESS CORROSION BEHAVIOR OF ALUMINUM ALLOYS IN SEAWATER BY GEORGE J. DANEK**

Donald O. Sprowis and J. G. Kaufman. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan 1972. 7 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00; MF \$0.95

It is shown that the method of testing with precracked specimens may be affected as much or more than traditional smooth specimen methods. On the basis of estimated threshold stress intensities obtained with precracked cantilever beam specimens, rankings of alloys are reported that are unrealistic compared to service experience and estimated threshold stresses obtained from tests of smooth beam specimens. Tests of the same alloys with bolt loaded precracked double cantilever beam specimens ranked the alloys in good agreement with rankings obtained from tests of smooth tensile specimens. Author

**N72-21921#** Societe Nationale Industrielle Aerospatiale, Paris (France)

**PARTICIPATION OF THE STUDY OF CORROSION UNDER TENSION OF CERTAIN HIGH RESISTANCE ALUMINUM ALLOYS (PARTICIPATION A L'ETUDE DE LA CORROSION SOUS TENSION DE CERTAINS ALLIAGES D'ALUMINIUM A HAUTE RESISTANCE)**

Robert Doste. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan 1972. 15 p. In FRENCH. (See N72-21900 12-32)

Avail. NTIS HC \$6.00; MF \$0.95

Experiments were conducted on corrosion under tension of two of the principal aluminum alloys used in the French aircraft

industry. A-U2GN and A-U4SG. A number of systematic tests were made using classical tests methods under conditions of flexure, with a constant imposed load. Processes occurring during corrosion and stress corrosion are most often electrochemical reactions and certain study techniques are described for electrochemical methods, in order to establish a correlation between observed phenomena and the particular microstructures of the alloys. In the case of the A-U2GN alloy, an explanation is advanced based on sensitivity to intercrystalline corrosion and the role of constraint, as well the desensitizing which occurs after proper heat treatment. Heat treatment of the alloy A-U4SG diminishes the susceptibility of the material to intercrystalline corrosion, while sensitivity to stress corrosion remains significant. The influence of aeration on the solution appears to be of major importance. Transl. by K.P.D.

**N72-21922#** Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn (West Germany)

**RESULTS OF COMPARATIVE STRESS CORROSION TESTS ON AlZnMgCu-ALLOYS USING DIFFERENT TYPES OF SPECIMENS**

Werner Lehmann. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan 1972. 15 p. (See N72-21900 12-32)

Avail. NTIS HC \$6.00; MF \$0.95

In order to evaluate and to compare the stress corrosion behavior of more complicated structural parts for example die forgings from the two different alloys 7079-T6 and AZ 74-61, various types of specimens were taken from critical locations on the forging. These locations are the area around the jack point hole, the main parting plane, and the area of the first two rows of bolt holes. C-rings, precracked DCB specimens, and smooth tension specimens were examined, using a standard 3.5% NaCl alternate immersion test. The test specimens were periodically inspected in order to find out the time to failure (tension specimens), the time to the first crack or to complete fracture (C-rings), and the crack length as a function of time as well as the threshold stress value (DCB specimens). The results show that forgings from the alloy AZ 74-61 are superior to those of 7079-T6. Author

**N72-21923#** Carpenter Technology Corp., Reading, Pa.  
**STRESS CORROSION CRACKING OF MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS**

Michael Henthorne. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan 1972. 8 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00; MF \$0.95

Stress corrosion cracking tests on two precipitation-hardened stainless steels, Custom 455 and Custom 450, were used to study the effects of heat treatment, product size, type of test specimen, and test environment. Smooth specimens (tensile bent beam and U-bend) and precracked cantilever beams were tested in sodium chloride solution, salt spray and a natural marine atmosphere. The cracking resistance of Custom 455 improves significantly as the aging temperature is increased, i.e. as the yield strength decreases and the toughness increases. Specimens cut from large product sizes (e.g. billet) have lower fracture toughness than smaller sizes (e.g. bar). The differences between stress corrosion and cracking in galvanic corrosion situations are discussed. Author

**N72-21924#** Societe Nouvelle des Acieries de Pompey (France)  
**INVESTIGATION OF AN ACCELERATED STRESS CORROSION CRACKING METHOD**

M. Hugo, J. Bellot, and E. Herzog. In AGARD Specialists Meeting on Stress Corrosion Testing Methods. Jan 1972. 11 p. refs. (See N72-21900 12-32)

Avail. NTIS HC \$6.00; MF \$0.95

An accelerated slow strain rate tensile method of testing is suggested which may be useful for inspection purposes. Slow straining in nitrate, NaOH, and acid environments are described. Author

**N72-21925\*** United States Steel Corp., Monroeville, Pa.  
Applied Research Lab

**MICROSCOPIC IDENTIFICATION OF STRESS CORROSION CRACKING IN STEELS WITH HIGH YIELD STRENGTH**

E. H. Phelps. In AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 14 p refs (See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

The microscopic features of stress corrosion cracking in steels with high yield strength are reviewed with the objective of establishing specific characteristics by which stress corrosion can be identified. Photomicrographs of stress corrosion cracking obtained under known exposure conditions on specimens of alloy steels, of precipitation hardenable stainless steels, and of maraging steels are presented and discussed. The most consistent feature of stress corrosion cracking in these steels is that it usually is initiated at multiple sites on the steel surface. Cracking may be intergranular or transgranular, depending on the alloy system and the environment. Branching occurs in some instances but is not a consistent characteristic of stress corrosion cracking in steels with high yield strength. Author

**N72-21926\*** National Aeronautics and Space Administration  
Langley Research Center, Langley Station, Va.

**HOT SALT STRESS CORROSION CRACKING OF TITANIUM ALLOYS: OVERVIEW AND IMPACT ON SPACE SHUTTLE APPLICATION**

W. Barry Lisagor and James E. Gardner. In AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 10 p refs (See N72-21900 12-32)

(NASA TM X-68304) Avail NTIS CSCL 11F

The test program described was conducted to determine if onset of hot salt stress corrosion cracking would occur in the cumulative exposure of time, temperature, and stress currently considered for titanium heat shields in the shuttle mission. In addition, efforts were made to assess the effects of cyclic exposure on cracking to compare the resistance to cracking of the two proposed prime candidate alloys (Ti-6Al-4V and Ti-6Al-2Sn-4Zr-2Mo) and to determine the effect of Mach 3 airflow on cracking behavior. The results indicate that cracking will occur on salt coated specimens continuously exposed in laboratory ovens for 100 hours at temperatures and stresses proposed for shuttle TPS application. However, both cyclic exposure and exposure in a Mach 3 airstream tend to decrease the damage observed. The Ti-6Al-4V alloy exhibited a higher threshold stress than the Ti-6Al-2Sn-4Zr-2Mo alloy but suffered more apparent damage once onset of cracking occurred. Author

**N72-21927\*** Battelle Memorial Inst., Columbus, Ohio. Corrosion Research Div.

**THE USE OF SLOW STRAIN RATE EXPERIMENTS IN EVALUATING RESISTANCE TO ENVIRONMENTAL CRACKING**

James E. Reinhold and Walter K. Boyd. In AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 5 p refs (See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

An experimental procedure is described for evaluating resistance to stress corrosion cracking. Relative degrees of susceptibility to environmental cracking and embrittlement can be determined as a function of mechanical ductility parameters (reduction in area, elongation, etc.) or as a function of electrochemical polarization parameters (electrode potential, pH, solution composition, etc.) by pulling cylindrical tensile specimens at a slow strain rate, while they are subjected to controlled electrochemical and environmental conditions (electrode potential, solution composition, temperature, etc.). Author

**N72-21928\*** Lockheed California Co., Burbank. Materials Research Lab.

**EXPERIMENTAL TECHNIQUES USED TO STUDY STRESS CORROSION MECHANISMS IN AIRCRAFT STRUCTURAL ALLOYS**

G. M. Hoch, W. E. Krupp, and K. E. Weber. In AGARD

Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 10 p refs (See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

Various techniques for the study of crack morphology, contaminant identification, and electrochemistry are considered. These include the use of time lapse photography, transmission and scanning electron microscopy, introduction of radioactive elements into the corrosive media under study, and pH and oxidation-reduction indicators. K. P. O.

**N72-21929\*** Ecole des Mines, Paris (France)

**FRACTURE INITIATION AND STRESS CORROSION CRACKING OF WELDED JOINTS OF ALPHA TYPE TITANIUM ALLOYS**

C. Chassignon and P. R. Krahe. In AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 6 p refs (See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

The almost instantaneous failure of some welded joints of certain Ti-Al-Sn alpha type alloys when in contact with carbon tetrachloride vapor, was studied and related to the slight surface contamination developed during argon arc welding. Analysis of the contaminated layers with the Castaing-Slodzian ion probe showed that a substantial amount of oxygen penetration had occurred during the welding operation. Testing showed that the susceptibility to stress corrosion was related to the extent of this penetration and microcracks were observed to form on the welded surfaces after loading, but before contact with the corrosion medium. As oxygen in solid solution in titanium reduces its ductility, these mechanical cracks propagate under the action of a constant load deeper into the more contaminated samples. Author

**N72-21930\*** Istituto di Ricerche Breda S.p.A., Milan (Italy)

**PRELIMINARY REPORT ON THE RESEARCH ON THE INFLUENCE OF THERMOMECHANICAL TREATMENTS ON STRESS CORROSION CRACKING BEHAVIOUR OF AISI 4340 STEEL**

R. DeSantis, L. Matteoli, and T. Songa. In AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 5 p refs (See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

Two grades of 4340 AISI steel were selected, air-melted and electroslag remelted. Experimental results are presented which were obtained by testing the hardness of two specimens of both steel grades subjected to thermomechanical treatments. The hardness recovery of the steels tempered at 200 C is very small, if not absent, and sometimes it takes place after a very long tempering time. This phenomenon is very marked for the 300 C tempered steels. In this case long tempering time causes a second decrease of the hardness in a way typical for aging phenomena. No clear relation seems to exist between the metallurgical grade of the material and the behavior upon deformation and second tempering. Moreover, there were significant differences in the results obtained on different specimens of the same material. Author

**N72-21931\*** Istituto Sperimentale dei Metalli Leggeri, Novara (Italy). Metallurgy Dept.

**PRELIMINARY RESULTS OF MECHANICAL AND STRESS CORROSION TESTS ON PLATES OF 7075 ALLOY PRODUCED BY A NEW PROCESSING TECHNIQUE**

E. Di Russo, M. Conserva, and M. Buratti. In AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 6 p (See N72-21900 12-32)

Avail NTIS HC \$6.00 MF \$0.95

The primary and secondary properties of hot rolled plates of 7075 alloy are briefly described. The materials show a reduction of the transverse effect compared to conventionally produced plates. Improved characteristics of ductility, fracture toughness and stress corrosion resistance were attained in the short transverse direction, along with strength levels equal to or higher than those of similar materials produced in the traditional way. Author



**N72-22918#** Advisory Group for Aerospace Research and Development, Paris (France).

**THE ACCUMULATION OF FATIGUE DAMAGE IN AIRCRAFT MATERIALS AND STRUCTURES**

J. Schijve (Natl. Aerospace Lab., Amsterdam) Jan. 1972 125 p refs

(AGARD-AG-157; AGARDograph-157) Avail NTIS

The available literature in the field of fatigue damage accumulation is surveyed and analyzed. Physical aspects of fatigue damage accumulation are discussed, including interaction and sequence effects. Empirical trends observed in variable-amplitude tests are summarized including the effects of a high preload, periodical high loads, ground-to-air cycles and the variables pertaining to program loading, random loading and flight-simulation loading. This also includes results from full-scale fatigue test series. Various theories on fatigue damage accumulation are recapitulated. The significance of these theories for explaining empirical trends as well as for estimating fatigue properties as a design problem is evaluated. For the latter purpose reference is made to the merits of employing experience from previous designs. Fatigue testing procedures are discussed in relation to various testing purposes. Emphasis is on flight-simulation tests. Finally several recommendations for further work are made. Author

**N72-24934#** Advisory Group for Aerospace Research and Development, Paris (France)

**NONDESTRUCTIVE TESTING AND INSPECTION APPLIED TO COMPOSITE MATERIALS AND STRUCTURES**

Feb. 1972 34 p refs Presented at 32d AGARD Structures and Mater. Panel Meeting, London, 31 Mar. 1971

(AGARD-R-590) Avail NTIS HC \$3.75

Papers on nondestructive testing applied to specimens and structural parts made of composite materials are presented. Various methods for failure inspection in carbon fiber composites and the possibilities and limitations of nondestructive inspection for quality control of airframes made of boron composites are discussed. For individual titles, see N72-24935 through N72-24936

**N72-24935#** Cranfield Inst. of Technology (England)  
**NONDESTRUCTIVE TESTING OF CARBON FIBRE REINFORCED POLYMERS**

C. N. Owston. In AGARD Nondestructive Testing and Inspection Applied to Composite Mater. and Structures Feb. 1972 p 1-21 Sponsored by Min. of Aviation Supply (See N72-24934 15-32)

Avail NTIS HC \$3.75

Ultrasonic, radiographic, eddy current and acoustic emission techniques are described, and possible failure mechanisms especially in fatigue, are discussed. It is concluded that nondestructive testing of carbon fiber composites is feasible. Care must be exercised in realizing that composites are not metals, and the interpretation of the indicators may be different. There are few case histories of failure with composites and predictions of the importance of defects is less certain than for metals. In general variations in the fibrous part of the composite are easy to locate and predictions of failure are easier to make. Techniques for looking at the matrix are not so good and there is less confidence in nondestructive testing where the performance of the component is markedly matrix dependent. Author

**N72-24936#** Air Force Materials Lab., Wright Patterson AFB, Ohio, Advanced Composites Div

**NONDESTRUCTIVE INSPECTION PRACTICES USED IN PRODUCTION OF COMPOSITE AIRFRAME STRUCTURES**

E. H. Jaffe. In AGARD Nondestructive Testing and Inspection Applied to Composite Mater. and Structures Feb. 1972 p 23-31 (See N72-24934 15-32)

Avail NTIS HC \$3.75

The possibilities and limitations of nondestructive inspection (NDI) applied to the quality control of a primary structural part made of boron composite are described. The NDI is discussed

using typical first generation high modulus composite aircraft empennage structures as examples of current practices in airframe production. The following subjects are discussed: (1) the most frequently occurring defects in manufacture of composite structures, (2) major NDI techniques currently available, and their limitations, (3) some newer techniques, and how they will fill the gap, and (4) problems of acceptance/rejection criteria, and how these decisions may be quantified. Author

**N72-28902#** Rolls-Royce, Ltd., Watford (England) Small Engine Div

**THE INFLUENCE OF FRETTING ON FATIGUE, PART 3**

W. J. Harris. Paris AGARD Jun. 1972 25 p

(AGARD-AR-45) Avail NTIS HC \$3.00

The effects of fretting on the fatigue properties of various materials are discussed. The development and evaluation of anti-fret media on titanium and aluminum alloys is described. The laboratory equipment used to conduct the experiments is illustrated. Tables and graphs are included to portray the results of the experiments. PNF

**N72-28983#** Advisory Group for Aerospace Research and Development, Paris (France)

**ACOUSTIC FATIGUE DESIGN DATA, PART 1**

A. G. R. Thomson (Eng. Sci. Data Unit Ltd.) May 1972 58 p refs

(AGARD AG-162 Pt. 1; AGARDograph-162 Pt. 1) Avail NTIS HC \$5.00

The problem of acoustic fatigue life of a structure subjected to jet noise is introduced. A framework of a design procedure applicable especially to skin panels is described. A method of estimating the near field sound pressure levels due to high velocity jet noise is described, including its limitations. Methods are described to predict the first two groups of natural frequencies of flat and singly curved skin-stringer structures with four different end conditions. The parameters considered are: (1) stringer torsional stiffness, (2) aspect ratio of a typical section, and (3) the number of half-waves across the frame pitch. A method of estimating the root mean square in rectangular skin panels subject to random acoustic loading is presented. Author

**N72-33915#** Advisory Group for Aerospace Research and Development, Paris (France)

**A COMPARISON OF METHODS USED IN FLUTTER RESEARCH**

H. G. Kuessner (DVL, Goettingen, West Germany) Aug. 1972 141 p refs

(AGARD-R-532) Avail NTIS HC \$9.25 CSCL 01C

The eigenfrequencies, modes and generalized masses of the F104G aircraft have been calculated from the drawings by the finite element method. The idealization of the structure by different types of elements and the formation of the corresponding mass matrix by adding lumped masses are described. The structure is divided into isolated substructures. By several condensation procedures the number of symmetric and antisymmetric unknowns has been reduced stepwise from 8250 + 7948 to 170 + 162. The rigid body modes have been eliminated by 3 + 3 supports and by a modified mass matrix. The results of the calculation of 24 modes are described and illustrated. Only 13 of them were comparable with corresponding measurements of two independent ground vibration tests. Whereas the eigenfrequencies agree within a few percent the mode shapes and the corresponding generalized masses show large differences and suggest the need for further improvements of the calculation method. Author

**N73-14898#** Advisory Group for Aerospace Research and Development, Paris (France)

**ACOUSTIC FATIGUE DESIGN DATA, PART 2**

A. G. R. Thomson (Engineering Sci. Data Unit Ltd.) and R. F. Lambert (Engineering Sci. Data Unit Ltd.) Nov. 1972 59 p refs

(AGARD AG-162 Pt. 2; AGARDograph-162 Pt. 2) Avail NTIS HC \$5.00

Data for use in aerodynamic structural design to reduce the effects of acoustic fatigue are presented. The subjects discussed are: (1) endurance of aluminum alloy structural elements subjected to acoustic loading; (2) natural frequencies of flat or singly curved sandwich panels with cores of zero flexural stiffness; and (3) stress response of flat or singly curved sandwich panels with cores of zero flexural stiffness subjected to random acoustic loading. Author

**N73-16616\*** Advisory Group for Aerospace Research and Development, Paris (France)

#### **SYMPOSIUM ON RANDOM LOAD FATIGUE**

Oct. 1972. 237 p. refs. Symp. held at 34th meeting of the AGARD Struct. and Mater. Panel, Lyngby, Denmark, 13 Apr. 1972, sponsored by Struct. and Mater. Panel (AGARD-CP-118). Avail. NTIS HC \$14.00

Physical aspects of fatigue damage accumulation and the significance of theories for the calculation of fatigue damage accumulation are reviewed. Influence of test frequencies on crack propagation rates, measurements of residual stresses in notched specimens, etc. are reported. For individual titles, see N73-16897 through N73-16904.

**N73-16897** Societe Nationale Industrielle Aerospatiale, Paris (France)

#### **A SHORT SURVEY ON POSSIBILITIES OF FATIGUE LIFE ASSESSMENT OF AIRCRAFT STRUCTURES BASED ON RANDOM OR PROGRAMMED FATIGUE TESTS**

W. Barrois. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 21 p. refs. (For availability see N73-16896 07-32)

After considering designers' needs and detailing the various physical parameters that are significant in the fatigue behavior of specimens and structures, several types of fatigue tests are reviewed. Prediction methods of structure fatigue life from fatigue tests of components, assemblies and structures undergoing constant amplitude loadings are surveyed. After considering fatigue tests under programmed loadings, the case of random loadings is briefly discussed. It is concluded that describing random loadings by their root mean squares is not sufficient to predict the fatigue lives of structures even when the shape of the load power spectrum is known, except in cases of comparative prediction where the only change is the general intensity of the spectrum. The possibility of test acceleration by increasing the general loading intensity is considered. Author

**N73-16898** Royal Aircraft Establishment, Farnborough (England); Structures Dept.

#### **SOME EFFECTS OF CHANGE IN SPECTRUM SEVERITY AND SPECTRUM SHAPE ON FATIGUE BEHAVIOUR UNDER RANDOM LOADING**

W. T. Kirkby. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 19 p. refs. (For availability see N73-16896 07-32)

The problem of reassessing the fatigue life of an aircraft structure is considered, when it is found that the spectrum of loads experienced in service differs from the load spectrum applied in test. Results obtained during fatigue tests on structural elements under random load spectra are used to illustrate some of the important considerations involved. It is shown that the use of an improved method of life prediction will generally lead to improved accuracy in reassessing life. Author

#### **N73-16899** National Aerospace Lab., Amsterdam (Netherlands); **THE ACCUMULATION OF FATIGUE DAMAGE IN AIRCRAFT MATERIALS AND STRUCTURES**

J. Schijve. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 120 p. ref. (For availability see N73-16896 07-32)

Physical aspects of fatigue damage accumulation are discussed, including interaction and sequence effects. Empirical trends observed in variable amplitude tests are summarized, including the effects of a high preload, periodical high loads, ground to air cycles, and the variables pertaining to program loading, random loading, and flight simulation loading. This also includes results from full scale fatigue test series. Various

theories of fatigue damage accumulation are recapitulated. The significance of these theories for explaining empirical trends as well as for estimating fatigue properties as a design problem is evaluated. Author

#### **N73-16900** National Aerospace Lab., Amsterdam (Netherlands); **EFFECTS OF TEST FREQUENCY ON FATIGUE CRACK PROPAGATION UNDER FLIGHT SIMULATION LOADING**

J. Schijve. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 17 p. refs. (For availability see N73-16896 07-32)

Fatigue crack propagation in 2024-T3 and 7075-Tc sheet material was studied at three test frequencies, viz. 10, 1, and 0.1 cycles per second. The flight simulation loading was based on a gust spectrum. The design stress level was adopted as a second variable. Differences between the crack propagation rates at the three test frequencies were small and unsystematic. The propagation was much slower than predicted from constant amplitude test data. Moreover, the macro-cracking behavior appeared to be different. Author

**N73-16901** Air Force Systems Command, Wright-Patterson AFB, Ohio

#### **CORRELATION BETWEEN LABORATORY TESTS AND SERVICE EXPERIENCE**

W. B. Miller and Holland B. Lowndes. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 10 p. refs. (For availability see N73-16896 07-32)

Direct comparisons are made between full scale fatigue test failures and actual service failures for several military aircraft. The correlations are discussed in relation to the basic fatigue test procedures and spectra used. Some methods used to force correlation where apparent correlation is lacking are discussed. The improvements in fatigue testing evolved over the past 25 years are summarized. Author

**N73-16902** Technical Univ. of Denmark, Lyngby, Dept. of Solid Mechanics

#### **ON RESIDUAL STRESSES DURING RANDOM LOAD FATIGUE**

Find Rotvel. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 14 p. refs. (For availability see N73-16896 07-32)

Data are presented from random fatigue tests on normalized carbon steel with 0.7% carbon. In notched specimens, a preload beyond the yield stress induced residual stresses around the notch. The residual stresses were measured with an X-ray measuring technique at intervals during the fatigue loading. Results from broadband and narrowband stochastic loading tests are compared with constant amplitude sinusoidal tests. Author

**N73-16903** Industrieanlagen Betriebsgesellschaft mbH, Ottonbrunn (West Germany)

#### **THE FATIGUE LIFE UNDER THREE DIFFERENT LOAD SPECTRA - TESTS AND CALCULATIONS**

Walter Schuetz. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 10 p. refs. (For availability see N73-16896 07-32)

One of the more important problems in the fatigue life prediction of military airplanes is caused by the difference between the load spectrum used in the full scale fatigue test and the load spectrum in service. Complex flight by flight tests with two types of notched specimens and a bolted joint simulating a skin fitting joint were carried out under three different load spectra occurring in service of a German military airplane. It is shown that Miner's rule can be used as a transfer function, relative Miner's rule to calculate the lives with high accuracy for the notched specimens and with less accuracy for the bolted specimens. Author

**N73-16904** Laboratorium fuer Betriebsfestigkeit, Darmstadt (West Germany)

#### **A RELATION BETWEEN MEASURED CENTER OF GRAVITY VERTICAL ACCELERATIONS AND THE LOADS AT THE TAIL OF A MILITARY AIRPLANE**

Otto Buxbaum. In AGARD Symp. on Random Load Fatigue, Oct. 1972. 15 p. refs. (For availability see N73-16896 07-32)

An engineering solution is presented for correlating two different random loads, time histories, based on measurements

of CG vertical accelerations and loads at the tailplane of an aircraft. The choice of instrumentation for a fleet airplane is described, and the measurements of operational loads are related to CG acceleration countings. Author

**N73-18918#** Advisory Group for Aerospace Research and Development, Paris (France)  
**AD HOC GROUP ON LOW-CYCLE HIGH TEMPERATURE FATIGUE**

J. M. Drapier (Centre de Rech. Met., Liege) Dec 1972 33 p refs

(AGARD R-604) Avail NTIS HC \$3.75

This report presents information on the activities in low cycle fatigue testing at high temperature (LCHTF) as received from 57 laboratories (industry and universities) in 9 NATO nations. The information includes the interest and activity in LCHTF testing techniques and conditions used. Author

**N73-18931#** Advisory Group for Aerospace Research and Development, Paris (France)

**SUMMARY AND EVALUATION OF SPECIALISTS MEETING ON STRESS CORROSION TESTING METHODS**

Donald E. Piper (Lockheed Missiles and Space Co., Inc., Palo Alto, Calif.) Dec 1972 11 p refs

(AGARD AR-52) Avail NTIS HC \$3.00

A summary is presented of the two-day Specialists Meeting on Stress Corrosion Testing Methods held during the 33rd Meeting of the Structures and Materials Panel of the Advisory Group for Aerospace Research and Development (AGARD) in Brussels, Belgium on October 5 and 6, 1971. The program was prepared to promote free and candid discussion of (1) the utility and significance of stress-corrosion data to current engineering and design practices; (2) the progress being made by NATO countries toward standardization of test techniques for stress-corrosion cracking; and (3) those test methods which might be recommended as standard techniques in the immediate future. Author

**N73-28884#** Advisory Group for Aerospace Research and Development, Paris (France)

**TECHNICAL EVALUATION REPORT ON THE AGARD SYMPOSIUM ON RANDOM LOAD FATIGUE**

Walter Schuetz (Industrieanlagen-Betriebsgesellschaft mbH) Jun 1973 13 p refs

(AGARD AR-54) Avail NTIS HC \$3.00

Brief summaries of the papers presented to the AGARD Symposium are presented. Conclusions and recommendations are included. Topics discussed include: full scale fatigue testing; crack propagation under flight-by-flight loading; fatigue life prediction; measurement and estimation of fatigue loads; damage accumulation; and service experience. FOS

**N73-29905#** Advisory Group for Aerospace Research and Development, Paris (France)

**SYMPOSIUM ON ACOUSTIC FATIGUE**

May 1973 273 p refs. Partly in FRENCH, mostly in ENGLISH. Papers presented at 35th Meeting of the Structures and Materials Panel, Toulouse 26-27 Sep 1972.

(AGARD CP-113) Avail NTIS HC \$15.75

The proceedings of a conference on acoustic fatigue and methods for reducing the effects of acoustic fatigue are presented. The subjects discussed include: (1) dynamic loading of aircraft surfaces due to jet exhaust impingement; (2) response of structures to aerodynamic loads; (3) design data for acoustic fatigue; (4) damping and composite structures; (5) sonic fatigue of bonded sandwich structures; and (6) assessment of test techniques for determining extent of acoustic fatigue. For individual titles see N73-29906 through N73-29923.

**N73-29906** Societe Nationale Industrielle Aerospatiale, Toulouse (France), Bureau d'Etudes

**KEYNOTE ADDRESS [ALLOCATION D'OUVERTURE]**

René Loubet. In AGARD Symp on Acoustic Fatigue, May 1973 2 p in FRENCH (For availability see N73-29905 20 32)

The complexity of problems raised before the conference on acoustic fatigue are discussed. Data cover constructive solutions, methods of prevention and control, and cooperation of various Nations in providing test procedures for the problems.

Transl. by EHW

**N73-29907** Dornier-Werke GmbH, Friedrichshafen (West Germany)

**INFLUENCE OF THE GROUND ON THE NEAR FIELD NOISE LEVELS OF JET-SUPPORTED V-STOL AIRCRAFT**

Rudolf Scholten. In AGARD Symp on Acoustic Fatigue, May 1973 12 p refs (For availability see N73-29905 20 32)

A method for calculating the near field noise level of a free jet (no ground effect) by means of a modified Lighthill theory using measured reference sound fields is explained. The shortcomings of the reference fields presently used, as well as a means to eliminate them, are shown. In addition, determining frequency spectra in the near sound field by means of a modified Strouhal number is described. The validity of the modified Lighthill theory is proven by means of two different engine jets. Wall jet sound fields (sound fields of an engine jet directed vertically towards the ground) and the influence of the essential parameters affecting the sound field are discussed. Increased noise levels due to ground effect are examined using V-STOL aircraft operation as an example. Author

**N73-29908\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**DYNAMIC LOADING OF AIRCRAFT SURFACES DUE TO JET EXHAUST IMPINGEMENT**

D. L. Lansing, J. A. Drischler, T. J. Brown, and J. S. Mixson. In AGARD Symp on Acoustic Fatigue, May 1973 9 p refs

(For availability see N73-29905 20 32)

CSCI 01C

High lift wing concepts being considered for application to commercial STOL transports are discussed. The flow patterns which produce dynamic loads on these wings are indicated. Measurements of surface pressure and acceleration on a one half scale model of an externally blown double slotted flap are reported. Root mean square values, power spectra, and scaling parameters are shown. Author

**N73-29909** National Aeronautical Establishment, Ottawa (Ontario), Structures and Materials Lab

**SURFACE PRESSURE FLUCTUATIONS FROM JET IMPINGEMENT ON AN INCLINED FLAT PLATE**

R. Westley, J. H. Woolley, and P. Brosseau. In AGARD Symp on Acoustic Fatigue, May 1973 18 p refs (For availability see N73-29905 20 32)

The influence of jet impingement pressure fluctuations on the structural design of short takeoff aircraft that use externally blown flaps is discussed. An experiment is described in which the surface pressure fluctuations on a flat plate were measured when an impinging cold air jet was blown at the plate with various speeds, inclination angles, and separation distances. The measured surface sound pressure levels and their spectra are reported. Author

**N73-29910\*** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**PRESSURE FLUCTUATION INPUTS AND RESPONSE OF PANELS UNDERLYING ATTACHED AND SEPARATED SUPERSONIC TURBULENT BOUNDARY LAYERS**

Charles F. Coe and Wei J. Chyu. In AGARD Symp on Acoustic Fatigue, May 1973 20 p refs (For availability see N73-29905 20 32)

CSCI 20D

Results of an investigation of surface pressure fluctuations and response of panels underlying attached and separated turbulent boundary layers and shock waves are summarized. Extensive tests of a large assortment of axisymmetric and two dimensional models have been conducted at transonic and supersonic Mach numbers to 3.6 to study the pressure fields. Assorted fixed edge flat panels have been tested at Mach numbers from 1.6 to 3.6 in attached and completely separated flow fields.

and also in mixed flow with a step induced shock wave oscillating on the panels. The surface pressure fluctuations are described in terms of broadband rms spectral density and spatial correlation information. The effectiveness of parameters for scaling the pressure fluctuations is also illustrated. Measurements of the amplitude and strain response of the panels are compared with response computations by the normal method of analysis.

Author

**N73-29911** National Research Council of Canada, Ottawa (Ontario)

**ACCURATE FINITE ELEMENT MODELLING OF FLAT AND CURVED STIFFENED PANELS**

G. M. Lindberg. In AGARD Symp on Acoustic Fatigue. May 1973. 21 p. refs. (For availability see N73-29905 20 32)

The dynamics of stiffened panels were analyzed using three different stiffener models. The more exact, complete beam finite element method was used in preference to the T-beam approach. A rectangular cylindrical shell finite element has been derived and was used to study the dynamic of singly curved stiffened panels. The major effect of the curvature is to increase the lowest frequencies and to broaden the banded nature of the results. Higher frequencies are little affected by the changes in curvature.

Author

**N73-29912** British Aircraft Corp (Operating) Ltd, Bristol (England); Structural Acoustics Group

**RESPONSE AND FATIGUE CHARACTERISTICS OF LIGHT ALLOY MACHINED PLANK STRUCTURES**

D. C. G. Eaton. In AGARD Symp on Acoustic Fatigue. May 1973. 17 p. refs. (For availability see N73-29905 20 32)

The response and fatigue characteristics of light alloy integrally machined planks are discussed. The vibration characteristics are compared with those of equivalent fabricated conventional structures. The characteristics are reviewed with emphasis on the related acoustic fatigue implications. Methods of predicting dynamic stresses are considered and comparisons are made with practical results. A research program for obtaining information to be used in preparing design guides is discussed. Problems associated with noise induced crack propagation in machined plank structures are reported.

Author

**N73-29913** Societe Nationale Industrielle Aerospatiale, Toulouse (France); Bureau d'Etudes

**EXPERIMENTAL RESEARCH ON THE RESPONSE OF AIRCRAFT STRUCTURES TO ACOUSTIC FATIGUE [RECHERCHE EXPERIMENTALE DE LA TENUE DES STRUCTURES D'AVION A LA FATIGUE ACOUSTIQUE]**

Jean Gay. In AGARD Symp on Acoustic Fatigue. May 1973. 9 p. In FRENCH. (For availability see N73-29905 20 32)

Data are presented on conditions known to cause acoustic fatigue and test conditions necessary for treating or correcting the problem. Data cover source of excitation, flight conditions and effects of aircraft critical zones on the problem. Several test procedures were examined.

Transl. by E. H. W.

**N73-29914** Engineering Sciences Data Unit, London (England)

**DESIGN DATA FOR ACOUSTIC FATIGUE**

A. G. R. Thomson and R. F. Lambert. In AGARD Symp on Acoustic Fatigue. May 1973. 16 p. refs. (For availability see N73-29905 20 32)

The development and preparation of data sheets for acoustic fatigue analysis and data recording are reported. The data are classified according to the following: (1) loading actions; (2) natural frequencies; (3) stress response of components under load; and (4) fatigue life estimation. Mathematical models for flat plate frequencies, the effect of finite core shear stiffness and the influence of core orthotropy are presented.

Author

**N73-29915** Southampton Univ (England); Inst of Sound and Vibration Research

**ESTIMATES OF THE RESPONSE OF BOX TYPE STRUCTURES TO ACOUSTIC LOADING**

Brian L. Clarkson. In AGARD Symp on Acoustic Fatigue. May 1973. 16 p. refs. (For availability see N73-29905 20 32)

A multicell box structure representing typical aircraft construction was tested in a high intensity noise facility. The vibration response of the internal ribs was studied. The test specimen was designed in such a way the ribs could be changed to produce variants in a typical tailplane design. A semi-empirical method for analyzing the response is developed and compared with the experimental results.

Author

**N73-29916** Lockheed California Co, Burbank

**CORRELATION OF SONIC FATIGUE FAILURES IN LARGE FAN ENGINE DUCTS WITH SIMPLIFIED THEORY**

Jaak Soovere. In AGARD Symp on Acoustic Fatigue. May 1973. 14 p. refs. (For availability see N73-29905 20 32)

The nature of the large fan jet engine intake duct noise and its effect on the duct structure are described. A simple semi-empirical method is developed to predict the stresses in intake duct structure induced by fan noise. The predicted stresses at the failure location show good correlation with random fatigue data for bending across the rivet line.

Author

**N73-29917** British Aircraft Corp, Weybridge (England); Commercial Aircraft Div

**EXPERIMENTALLY DETERMINED DAMPING FACTORS**

J. A. Hay. In AGARD Symp on Acoustic Fatigue. May 1973. 15 p. refs. (For availability see N73-29905 20 32)

The effect of damping on the response of a structure to acoustic excitation is discussed. The various parameters which induce damping are analyzed. Mathematical models are developed to show the damping ratio and the equations of motion for viscous and hysteresis damping. The test facilities and procedures for experimental determination of damping coefficients are reported.

Author

**N73-29918** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio

**DESIGN AND SONIC FATIGUE CHARACTERISTICS OF COMPOSITE MATERIAL COMPONENTS**

N. D. Wolf and M. J. Jacobson (Northrop Corp., Hawthorne, Calif.). In AGARD Symp on Acoustic Fatigue. May 1973. 18 p. refs. (For availability see N73-29905 20 32)

A summary of two programs concerned with the design and acoustic testing of composite material components is presented. Equations are developed for both a simplified theory and a more general theory in matrix form for predicting natural frequencies, mode shapes and stresses in unstiffened and cross-stiffened advanced composite panels subjected to acoustic loads. Sonic fatigue test results on simple 8-ply boron-epoxy and 6-ply cross-stiffened graphite-epoxy panels are described. This includes panel damping values, fatigue life, stress data and a description where appropriate, of panel fatigue failures. Also a series of 72 beam specimens was fatigue tested with shaker excitation to develop S-N data for various simulated joint configurations. The beams consisted of a graphite-epoxy or boron-epoxy material bonded or riveted to a graphite-epoxy or titanium alloy stiffener. S-N data up to 10 to the 8th power cycles were obtained. Frequencies and strains predicted by the analytical procedures are compared with experimentally measured values.

Author

**N73-29919** Rohr Corp, Chula Vista, Calif.

**SONIC FATIGUE OF DIFFUSION-BONDED TITANIUM SANDWICH STRUCTURE**

I. Moynhouse. In AGARD Symp on Acoustic Fatigue. May 1973. 15 p. refs. (For availability see N73-29905 20 32)

The sonic fatigue characteristics of titanium sandwich structures using a liquid interface diffusion (LID) bonding process are discussed. Test panels were subjected to sound levels of up to 170 db for extended time periods. Various failure modes and times to failure were observed. Sufficient strain and acoustic data were taken to develop a semi-empirical design analysis nomograph. A single degree of freedom random response equation combined with a finite element approach for determining natural frequencies and static stress values was used. The effect of skin repairs and facing to core bond voids were investigated by testing panels with programmed defects.

Author

**N73-29920** Aeritalia, Turin (Italy)

**ACOUSTIC FATIGUE TEST ON THE VFW-FOKKER VAK 191 B STRUCTURAL COMPONENTS**

Pietro Selvaggi and Angelo Lorea (Fiat SpA, Turin) In AGARD Symp on Acoustic Fatigue May 1973 16 p refs (For availability see N73-29905 20-32)

Near field noise and temperature measurements on 1/4 scale model of the VFW-FOKKER VAK 191 B aircraft indicated that critical environments will be induced on aircraft structural components during the VTO and STO configurations. The results of the structural response and endurance test performed on a fuselage skin panel and on a wing trailing edge flap are reported. The noise and temperature simulation procedure and the experimental facilities arranged for testing purpose are described. Author

**N73-29921** Royal Aircraft Establishment, Farnborough (England) Structures Dept

**SOME CONSIDERATIONS OF THE FATIGUE BEHAVIOUR OF ALUMINUM ALLOY STRUCTURES UNDER ACOUSTIC LOADING**

W T Kirkby In AGARD Symp on Acoustic Fatigue May 1973 14 p refs (For availability see N73-29905 20-32)

Data on the fatigue performance of aluminum alloy structural elements which represent typical skin-stringer attachments, or integrally-milled skin-stiffener configurations, for use in design against acoustic fatigue are discussed. The fatigue data have generally been obtained from tests under narrow-band random loading with zero mean stress in the skin. Some guidance is given on the allowances which should be made for differences in bandwidth and for effects of mean stress, when using such acoustic fatigue data. The tentative advice given is based on general experience of the fatigue behaviour of other types of structural elements under a wider range of random loading conditions. Some consideration is also given to some aspects of crack propagation under acoustic fatigue loading. In particular the problem of crack propagation under combined fatigue loading actions is discussed. Predictions of crack growth under cabin pressurisation and acoustic loading are used to illustrate the significance of the problem with reference to aircraft structures which must satisfy fail safe requirements. Author

**N73-29922** Hawker Siddeley Aviation, Ltd, Brough (England) ASSESSMENT OF SIREN TEST TECHNIQUES

Eric James Phillips In AGARD Symp on Acoustic Fatigue May 1973 18 p refs (For availability see N73-29905 20-32)

The siren as a test technique for the determination of response and life of aircraft structures subject to engine noise field excitation is discussed. A flat panel specimen is to be placed in the near noise field of a typical jet engine and its stress response measured. The specimen is placed in a siren and the response which was measured in the engine noise field reproduced as closely as possible. The differences in response is assessed with regard to the extrapolation of measured siren fatigue life to service environments. Specimen responses in the engine noise field and in the siren are compared with the theoretically predicted response using methods of varying complexity. Author

**N73-29923** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio

**SONIC FATIGUE RESISTANCE OF LIGHTWEIGHT AIRCRAFT STRUCTURES**

R C W VanderHayde and A W Kolb In AGARD Symp on Acoustic Fatigue May 1973 17 p refs (For availability see N73-29905 20-32)

An experimental program under which the response and sonic-fatigue resistance of lightweight aircraft structures were investigated is presented. The program involved a series of aluminum alloy panels of bonded beaded and skin-stringer design. A total of 60 bonded beaded and 60 skin-stringer type test specimens was investigated. The panels were tested in groups of 5 or 10 at 4 different overall sound pressure levels to obtain test results with a high level of confidence. The data reported include mode shapes, panel clamping ratios, linearity of response, fatigue life, and failure location. For some panel configurations data to above 10 to the 8th power cycles were obtained. The

test facility, test fixture, noise source, testing technique, and instrumentation used, are described along with the test results. Fatigue failure detection techniques are discussed. The test results are compared with stress predictions from various available methods. Author

**N73-29924#** Advisory Group for Aerospace Research and Development, Paris (France)

**FATIGUE LIFE PREDICTION FOR AIRCRAFT STRUCTURES AND MATERIALS**

May 1973 223 p refs  
(AGARD-LS-62) Avail: NTIS HC \$13 25

Procedures for predicting the fatigue life of aircraft structures are described. The subjects discussed are: (1) methods of stress measurement; analysis for fatigue life evaluation; (2) application of fracture mechanics principles in design and analysis of aircraft structures; (3) effects of corrosion fatigue; (4) crack growth prediction techniques; and (5) development of analytic theory for fatigue. For individual titles, see N73-29925 through N73-29934.

**N73-29925** National Aerospace Lab., Amsterdam (Netherlands)

**ASPECTS OF AERONAUTICAL FATIGUE**

J Schijve In AGARD Fatigue Life Prediction for Aircraft Structure and Mater May 1973 23 p refs (For availability see N73-29924 20-32)

The evaluation of the fatigue quality of an aircraft is discussed. Several steps, such as: (1) determination of the fatigue load environment; (2) response of the aircraft structure; (3) internal load distributions; and (4) estimation of the fatigue properties are involved. The fatigue properties comprise fatigue life, crack propagation and residual strength. The latter two items together with inspection procedures are qualifying the fail-safe. The above aspects are analyzed with reference to the contributions of design efforts, calculations, testing, inspections and fatigue load monitoring. Author

**N73-29926** Laboratorium fuer Betriebsfestigkeit, Darmstadt (West Germany)

**METHODS OF STRESS-MEASUREMENT ANALYSIS FOR FATIGUE LIFE EVALUATION**

O Buxbaum In AGARD Fatigue Life Prediction for Aircraft Structure and Mater May 1973 19 p refs (For availability see N73-29924 20-32)

The possibilities and limitations of a spectral presentation of measured stress-time histories are described. A concept is presented which distinguishes between stresses due to random vibrations and stresses due to manoeuvres, variations of payload, and which is suitable for any theoretical or experimental fatigue life evaluation. Reference is made also to fatigue testing under random loading and to the derivation of external loads. Author

**N73-29927** Hawker Siddeley Aviation, Ltd, Hatfield (England) THE USE OF COUNTING ACCELEROMETER DATA IN FATIGUE LIFE PREDICTIONS FOR AIRCRAFT FLYING IN COMPLEX ROLES

J A B Lambert In AGARD Fatigue Life Prediction for Aircraft Structure and Mater May 1973 18 p refs (For availability see N73-29924 20-32)

The use of counting accelerometer data for predicting the fatigue life of aircraft flying in various load conditions is discussed. Methods for conducting a full scale fatigue test are explained. The application of load and acceleration relationships for fighter and transport aircraft is analyzed. The characteristics of fatigue meters for obtaining accurate load data are described. Author

**N73-29928** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio

**THE USE OF FRACTURE MECHANICS PRINCIPLES IN THE DESIGN AND ANALYSIS OF DAMAGE TOLERANT AIRCRAFT STRUCTURES**

Howard A Wood In AGARD Fatigue Life Prediction for Aircraft Structure and Mater May 1973 13 p refs (For availability see N73-29924 20-32)

Current trends in the usage of high strength structural materials for aerospace applications are reviewed. The manner in which fracture control procedures may be implemented to achieve a higher degree of damage tolerance are discussed. The application of fracture requirements to two current designs is related. These experiences have contributed to the formulation of specifications for use across the board on all new systems. Important aspects of the proposed USAF damage tolerance criteria, including initial damage assumption and crack growth analyses, are discussed. Author

**N73-29929** Battelle-Northwest, Richland, Wash.  
**CORROSION FATIGUE - OR - HOW TO REPLACE THE FULL SCALE FATIGUE TEST**

W. E. Anderson. In AGARD Fatigue Life Prediction for Aircraft Struct and Mater. May 1973. 10 p. refs. (For availability see N73-29924 20-32)

The effect of environment and stress-cycling in real-time on in-service structural failure is discussed. Comparative calculations of cracking from a fastener hole are used as the basis of the investigation. A method to overcome the limitations of full-scale fatigue test data is proposed. The method involves sacrificial examination of selected portions of airframes and testing of structural materials under several environmental and stress histories. Application of the procedure for calculating scheduled repair times for individual airframes based on respective flight experiences is proposed. Author

**N73-29930** Aeronautical Systems Div., Wright-Patterson AFB, Ohio  
**ON FATIGUE ANALYSIS AND TESTING FOR THE DESIGN OF THE AIRFRAME**

Walter J. Cichlow. In AGARD Fatigue Life Prediction for Aircraft Struct and Mater. May 1973. 36 p. refs. (For availability see N73-29924 20-32)

The experimental and analytical techniques for controlling time to fatigue crack initiation in design of aircraft structure are reviewed to define improvements that may be gained from available research knowledge. Discrepancies among simple theory, experiment, and service are being better explained by accountability for residual stress systems created by higher than average loading peaks recurring randomly throughout the service load spectrum. Analytical accounting for the generation, decay, and recreation of residual stress spectra is an essential adjunct to the experimental approach for not all parts can be critically tested, and not all load spectra variations can be accommodated in test. Recent advances in residual stress analyses are reviewed. Failure theory, interaction matrix, chemical (corrosion), and mechanical (fretting) environmental aspects are explored. Variability of results are discussed in terms of design life reduction factors. Author

**N73-29931** Battelle-Northwest, Richland, Wash.  
**A RATIONAL ANALYTIC THEORY OF FATIGUE REVISITED**

W. E. Anderson. In AGARD Fatigue Life Prediction for Aircraft Struct and Mater. May 1973. 9 p. refs. (For availability see N73-29924 20-32)

Fatigue of airframe structures is viewed from the standpoint of crack initiation and extension. By employing a rational analytic theory of fatigue, the aspect of crack extension is treated in terms of the maximum stress-field-parameter, and the minimum to maximum load excursion ratio. Initiation is treated as that period prior to development of a well-behaved crack. A number of airframe fatigue test data are thereby examined and compared with interpreted service experiences. The principal differences seem to stem from environmental influences in service that are not represented during laboratory experiments. Author

**N73-29932** Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio  
**A SUMMARY OF CRACK GROWTH PREDICTION TECHNIQUES**

Howard A. Wood. In AGARD Fatigue Life Prediction for Aircraft Struct and Mater. May 1973. 31 p. refs. (For availability see N73-29924 20-32)

The use of material growth rate data and analytical retardation models in predicting crack growth under variable amplitude loading is reviewed. Retardation models of current interest are discussed and compared. An effective stress model is described, including the mathematical formulation, applicability and usage limitations. Comparison of analyses and tests for typical spectra are shown. A primary factor in the accurate prediction of spectrum crack growth behavior is the proper representation of basic growth rate data including consideration of R factor shift and possible limit, threshold levels of stress intensity, closure effects and environment. The relative significance of each of these parameters on total crack growth life is discussed. Author

**N73-29933** Hawker Siddeley Aviation, Ltd., Hatfield (England)  
**THE R.A.S. - ESDU CUMULATIVE DAMAGE HYPOTHESIS**

J. A. B. Lambert. In AGARD Fatigue Life Prediction for Aircraft Struct and Mater. May 1973. 16 p. refs. (For availability see N73-29924 20-32)

The limitations of a cumulative damage hypothesis for estimating the fatigue life of airframes are described. The major source of error is identified as being due to neglecting the redistribution of stresses that occurs when a part yields at a stress concentration. A method which takes the localized yielding effects into account is proposed. The procedure involves estimating the change in the actual mean stress of subsequent stress cycles after yielding has occurred. Author

**N73-29934** Industrieanlagen-Retriebsgesellschaft mbH, Ottobrunn (West Germany)  
**FATIGUE LIFE PREDICTION: A SOMEWHAT OPTIMISTIC VIEW OF THE PROBLEM**

Walter Schuetz. In AGARD Fatigue Life Prediction for Aircraft Struct and Mater. May 1973. 32 p. refs. (For availability see N73-29924 20-32)

Lack of correlation between the fatigue life predicted from calculations and tests and the service life actually obtained is discussed. This may be due to one or several of the following causes: (1) incorrect load spectra were assumed in the calculations and applied in the tests including the full scale test; (2) Miner's Rule was used in the life calculations; (3) unexpected failures occurred, starting from material flaws in non-redundant structure built of high strength materials; and (4) the load sequence in the tests including the full scale test was too much simplified. It is suggested that major improvements in the accuracy of fatigue life prediction should be possible using modern methods and modern data. These are compared to hitherto existing methods for life calculations in the design stage, for component testing and for the full scale fatigue test. Author

**N74-15596\*** Advisory Group for Aerospace Research and Development, Paris (France)  
**SECOND SYMPOSIUM ON STRUCTURAL OPTIMIZATION**  
Nov. 1973. 390 p. refs. Struct and Mater. Panel Symp. held at Milan, 2-4 Apr. 1973.  
(AGARD CP 123). Avail. NTIS. HC \$21.50

The symposium papers are presented with the major emphasis placed on methods which are already in, or are rapidly nearing, a practical operational status. The papers demonstrate a remarkable diversity of practical applications of the various approaches to structural optimization. For individual titles see N74-15597 through N74-15617.

**N74-15597** Brown Univ., Providence, R.I.  
**NECESSARY AND SUFFICIENT CONDITIONS FOR GLOBAL STRUCTURAL OPTIMALITY**

W. Prager. In AGARD Second Symposium on Structural Optimization, Nov. 1973. 12 p. refs. Sponsored by AROD. (For availability see N74-15596 06-3)

A method is discussed by which necessary and sufficient conditions for global structural optimality can be derived for a wide variety of design constraints. The importance is stressed of conditions that are not only necessary but also sufficient for global optimality. To present the method, minimum mass design of a truss with prescribed elastic compliance is treated when

the truss is to be derived from a given basic layout, and when the layout is left open. Use of the method for other constraints, alternative states of loading, and structures of other types is illustrated by examples. Computational aspects of structural optimization are discussed. Author

**N74-15598** Bell Aerospace Co. Buffalo, N.Y. Structural Systems Dept.

**SURVEY OF THE STATE-OF-THE-ART OF OPTIMIZATION TECHNOLOGY WITHIN NATO COUNTRIES**

Ronald A. Gallatiy. In AGARD Second Symp. on Structural Optimization. Nov. 1973. 20 p. refs. (For availability see N74 15596 06 32)

The Working Group on Optimization of the Structures and Materials Panel AGARD as part of its continuing activity sponsored a survey of the state-of-the-art in structural optimization and automated design technology within NATO countries. The results of meetings held with representatives of Italy, Germany, Holland, Belgium, France, and Great Britain are presented along with submittals from Denmark, Norway, Canada, and Portugal. A brief survey of the state-of-the-art in the United States is also included. Author

**N74-15599** Air Force Flight Dynamics Lab., Wright-Patterson AFB Ohio. Synthesis Group.

**APPLICATION OF OPTIMALITY CRITERIA APPROACHES TO AUTOMATED DESIGN OF LARGE PRACTICAL STRUCTURES**

V. B. Venkayya, N. S. Khor, and L. Berke. In AGARD Second Symp. on Structural Optimization. Nov. 1973. 19 p. refs. (For availability see N74 15596 06 32)

A unified approach for the derivation of optimality criteria for the design of optimum structures is presented. The design conditions included requirements of generalized stiffness, specified displacements, dynamic stiffness and stiffness for general stability. Recursion relations for achieving the optimality criteria are derived for all these cases. Both single and multiple stiffness requirements are considered. The formulation considers isotropic, anisotropic and layered composite structures. Four categories of design examples are selected to illustrate the versatility of the method. The first group is designed for static loads with constraints on stresses, displacements and minimum sizes. The second group of examples is designed for dynamic loads with periodic time dependence. The third group consists of layered composite structures subjected to static loads. The fourth group is concerned with static stability requirements. The results of many of these examples are compared with those available in the literature. Author

**N74 15600** Case Western Reserve Univ., Cleveland, Ohio.  
**RECENT DEVELOPMENTS IN THE CASE OPTIMIZATION PROGRAM**

Fred Moses. In AGARD Second Symp. on Structural Optimization. Nov. 1973. 8 p. refs. (For availability see N74 15596 06 32)

Three optimization problem types and respective solutions are identified. A penalty function approach is used for design of elements such as welded girders, columns, prestressed concrete beams, and simple gabled frames which have complex design code constraints but relatively few design variables. The second problem type includes a modified Zoutendijk feasible direction method and has been used for structural system constraints such as deflection, stability and flutter. The third problem type includes discrete variables involving sizes, inventory and fabrication costs and can often be handled by dynamic programming. The influence of optimum design on safety and reliability remains a continuing area of research and models of reliability analysis and design are discussed. Author

**N74 15601** Liverpool Univ. (England). Dept. of Civil Engineering.

**STRUCTURAL DESIGN APPLICATIONS OF GEOMETRIC PROGRAMMING**

A. B. Templeman and S. K. Winterbottom. In AGARD Second Symp. on Structural Optimization. Nov. 1973. 16 p. refs. (For availability see N74 15596 06 32)

The technique of geometric programming is described for the solution of non-linear optimization problems. The form in which the method was first developed, now usually known as prototype geometric programming, is presented in some detail and this is followed by a description of more recent developments which have considerably extended the scope and usefulness of the method. It is demonstrated that many problems arising in optimum structural design may be formulated in such a way as to be easily and rapidly solved using geometric programming. Finally the problem of designing minimum weight space trusses to satisfy stress and deflection constraints is examined and it is shown that by using a further extended approximate form of geometric programming optimum designs may be derived iteratively using only a few cycles of analysis and iteration. Author

**N74 15602** Royal Aircraft Establishment, Farnborough (England). Structures Dept.

**THE OPTIMISATION OF STATICALLY INDETERMINATE STRUCTURES BY MEANS OF APPROXIMATE GEOMETRIC PROGRAMMING**

A. J. Morris. In AGARD Second Symp. on Structural Optimization. Nov. 1973. 17 p. refs. (For availability see N74 15596 06 32)

Application of approximate geometric programming in the least weight design of statically indeterminate structures is described. It is shown how the facility of standard geometric programming to obtain bounds on a minimum weight design is preserved. The advantages of coupling geometric programming with a modern projected gradient method are also described. Numerical examples, which are used to illustrate the method, involve up to two load conditions with active constraints on stresses and displacements. Author

**N74 15603** Middle East Technical Univ., Ankara (Turkey).  
**APPLICATION OF DISCRIMINATE FUNCTION TECHNIQUE TO RANDOM SEARCH**

M. O. Keirman and M. Akguel. In AGARD Second Symp. on Structural Optimization. Nov. 1973. 10 p. refs. (For availability see N74 15596 06 32)

Statistical methods of discrimination were used as a decision-making tool in nonlinear, constrained, optimization problems. A linear discriminant function form is proposed as an aid to the preliminary designer. It is assumed that a design problem, with a large number of variables is given, and only an approximate answer that will aid the decision maker is required. The possibility is discussed of representing each design point in a reduced design space by means of pooling the variables. The optimization procedure based on a combination of direct search and discriminant function method was applied to typical test problems and to a grid design problem. The grid has a stiffness dependent loading condition, with the fitness function not directly dependent on some of the design variables. This particular choice was made in order to illustrate the complete generality of the method. Author

**N74 15604** Istituto di Elaborazione dell'Informazione, Pisa (Italy).

**INTEGER PROGRAMMING ALGORITHMS FOR OPTIMUM STRUCTURAL DESIGN**

Ardo Cella. In AGARD Second Symp. on Structural Optimization. Nov. 1973. 14 p. refs. (For availability see N74 15596 06 32)

A large variety of structural design problems is constrained by the practical necessity of selecting the design parameters from an enumerable set of discrete values. The resulting solution space has a grid like pattern, and an enumerative combinatorial algorithm seems most appropriate for the problem. A branch and bound algorithm was developed for the optimal design of a large class of linear elastic structures, discretized into finite elements, and subjected to stress, deflection and stiffness constraints. Sensitivity coefficients were developed for all those constraints. The algorithm is of the enumerative kind, having decision rules that are specific to the solution space associated with structural problems. The resulting numerical procedure was applied to the optimal design of a number of aerospace type structures, such as the ban-mechanism of a large scale radio telescope, and the supporting structure of an orbiting telescope. Author

N74-15605 Politecnico di Milano (Italy)

# SHAPE OPTIMIZATION USING MATHEMATICAL PROGRAMMING AND MODELLING TECHNIQUES

Edmonds, Vitoello. In AGARD Second Symp on Structural Optimization, Nov 1973. 11 p. refs. (For availability see N74 15596 06 32)

Structural optimization of elastic models with design variables describing their geometry is considered. The use of mathematical programming for practical design is shown in connection with a progressive (quadratic) fitting of the constraints in the space of design variables (modelling). The method proves successful for a few design variables and for smooth variations of stresses and loads with the design variables. However it seems to make feasible the use of optimization for practical design in some fields where earlier optimization methods implied very heavy calculations. Applications to the optimum design of gravity dams, considering both their static (finite element analysis) and dynamic (seismic) behavior, is presented. Author

N74-15606 Cranfield Inst of Technology (England) Coll of Aeronautics

# THE DESIGN OF COMPATIBLE STRUCTURES

O. M. Richards. In AGARD Second Symp on Structural Optimization, Nov 1973. 13 p. refs. (For availability see N74 15596 06 32)

A format for the economical description of complex structures for design purposes is introduced. Sufficient conditions under which a redundant configuration may be fully stressed are formulated. These conditions are used to determine a wide range of simple frameworks with this property. Some characteristics of sequential redesign trajectories are described utilizing the format. Author

N74-15607 Cornell Univ., Ithaca, N.Y. Dept of Structural Engineering

# OPTIMIZATION OF STIFFENED PANELS

R. H. Gallagher and W. E. Falby. In AGARD Second Symp on Structural Optimization, Nov 1973. 14 p. refs. (For availability see N74 15596 06 32)

A program is described for the structural optimization of longitudinally stiffened plates loaded in compression. The complexity of the problem is reduced significantly by exploiting the understanding of the initial buckling and postbuckling behavior of these panels in order to reduce the number of inequality constraint conditions. An interior penalty function technique is combined with an unconstrained optimization algorithm to produce an efficient optimization program. Results generated by the program are compared with relevant data from design charts. Author

N74-15608 Technical Univ of Denmark, Lyngby, Dept of Solid Mechanics

# OPTIMAL JOINT POSITIONS FOR SPACE TRUSSES

Pauli, Pedersen. In AGARD Second Symp on Structural Optimization, Nov 1973. 14 p. refs. (For availability see N74 15596 06 32)

An iterative procedure is presented for determining the joint positions corresponding to a minimum mass space truss. Displacement constraints and non-constant stress constraints (stability) are taken into account. The truss is presumed to carry consecutively a large number of different systems of forces. The iteration includes a sequence of linear programming problems (SLP with move limits) and for each of these problems only the nearby constraints are considered. Analytical expressions are given for the gradients describing the linear problems. Author

N74-15609 Stanford Univ., Calif. Dept of Aeronautics and Astronautics

# APPLICATION OF A GENERAL METHOD FOR FLUTTER OPTIMIZATION

R. F. Taylor, JAFFDL and L. B. Gwin. In AGARD Second Symp on Structural Optimization, Nov 1973. 14 p. refs. (For availability see N74 15596 06 32)

(Contract F33615 70 C 1282, F33615 72 C 1275)

Design of modern aircraft requires that aeroelastic considerations be included as early as possible to avoid addition of excessive weight for prevention of aeroelastic instabilities. A computational approach for minimum weight design of flutter critical lifting surfaces is presented which has generality in the selection of analysis methods and demonstrated applicability to problems involving a large number of design variables. A key feature of the method is the calculation of derivatives of the flutter speed with respect to design parameters. These analytically derived derivatives are computed in such a way that they are economical for large scale problems. The mathematical programming method which utilizes the derivatives is based on the method of feasible directions with a simplex algorithm to solve a linearized direction finding problem. Results are presented which show that the method can efficiently reduce the structural weight of lifting surface designs involving at least 99 design variables. Author

N74-15610 Bell Aerospace Co., Buffalo, N.Y. Structural Systems Dept

# MINIMUM WEIGHT DESIGN OF SURFACE EFFECT VEHICLES USING THE SIEVE SEARCH TECHNIQUE

James R. Ball and Ronald A. Gellatly. In AGARD Second Symp on Structural Optimization, Nov 1973. 14 p. refs. (For availability see N74 15596 06 32)

Past and present methods for the optimization of structural systems for minimum weight use mathematical programming or numerical search techniques. This procedure has led to an intractable situation whereby large computer costs and mathematical complexity arises. More economical and more flexible procedures for structural optimization of large scale systems have therefore been sought. A new approach to determine the minimum weight of such systems has been developed and is labeled the sieve search technique. In performance of optimization studies using this technique, the guiding philosophy was to generate an optimal arrangement of preoptimized components. An essential element of the technique is the use of data banks which contain minimum weight and associated geometry of the structural components. These banks are generated using classical methods of optimization. An additional facet of the technique is the use of simplified engineering analysis methods during the redesign phase of the optimization cycle. Author

N74-15611\* National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

# AUTOMATED SIZING OF LARGE STRUCTURES BY MIXED OPTIMIZATION METHODS

Jaroslaw Sobieszcanski and David Loendorf. In AGARD Second Symp on Structural Optimization, Nov 1973. 12 p. refs. (For availability see N74 15596 06 32)

A procedure for automating the sizing of wing/fuselage airframes was developed and implemented in the form of an operational program. The program combines fully stressed design to determine an overall material distribution with mass strength and mathematical programming methods to design structural details accounting for realistic design constraints. The practicality and efficiency of the procedure is demonstrated for transport aircraft configurations. The methodology is sufficiently general to be applicable to other large and complex structures. Author

N74-15612 British Aircraft Corp., Preston, England, Military Aircraft Div.

# OPTIMISATION OF AIRCRAFT STRUCTURES WITH MULTIPLE STIFFNESS REQUIREMENTS

F. C. Tong and R. E. Kent. In AGARD Second Symp on Structural Optimization, Nov 1973. 14 p. refs. (For availability see N74 15596 06 32)

A general optimality theorem is presented for structures whose members have stiffnesses proportional to their masses and which are designed by generalized stiffness requirements. The theorem is used to derive an iterative procedure for optimum structure design. Modifications to the basic theorem include practical constraints such as maximum material gauges and strength or stability requirements to be introduced. The method can be used where stiffness requirements are directly specified for a loading



conditions or where vibration frequency or aeroelastic efficiency requirements are stipulated. A useful feature of the method when used in conjunction with automated design procedures, is that the optimization can operate with real structure variables and constraints so that there is no subsequent design operation required to convert idealised structure dimensions to feasible detail sizes. Several examples are quoted to show that very favorable results and computing times are obtainable for demonstration problems. The ability to handle major structural optimization is also illustrated by applications to actual airframe structures. Author

**N74-15613** Grumman Aerospace Corp., Bethpage, N.Y. Structural Mechanics Section.  
**APPLICATION OF A DESIGN ANALYSIS SYSTEM TO A SPACE SHUTTLE PRELIMINARY DESIGN** c31  
W. Lansing, P. Mason, W. Dwyer and J. C. Cooper. In AGARD Second Symp. on Structural Optimization, Nov. 1973. 14 p. refs. (For availability see N74-15596 06-32)

In a broad sense, interdisciplinary design analysis systems are optimization tools, of which the specialized computer programs which resize structures of fixed topology are merely a part. This interrelationship is portrayed by describing briefly the Integrated Design Analysis System (IDEAS) and showing how its Automated Structural Optimization Program (ASOP) is incorporated within the basic system. Application to a preliminary design of the space shuttle is presented and ways in which ASOP is being improved are discussed. Author

**N74-15614** Messerschmitt Boelkow Blohm G.m.b.H., Hamburg (West Germany). Stress Dept.  
**OPTIMIZATION AND DESIGN OF THE REAR FUSELAGE OF THE A 300 B AIRCRAFT STRUCTURE** c02  
D. Schulz. In AGARD Second Symp. on Structural Optimization, Nov. 1973. 15 p. refs. (For availability see N74-15596 06-32)

A method is described for the automatically controlled calculation of a skin stringer structure. The method was programmed and applied for the first time for the development of the Airbus A 300 B. The method can be considered as a link in a process chain, the target of which is the overall development of aircraft structures. It starts with the calculation of statically indeterminate forces and ends up with the static strength analysis. Input and output data for the calculations of statically indeterminate forces are used as input data for structure dimensioning or strength analysis program. The structure dimensioning program iteratively modifies the originally defined wall thicknesses so that the reserve factors required to prevent failure under tensile, compression and shear loads are reached or only slightly exceeded in all critical load cases. The originally defined structural concept (stringer and frame spacing as well as stringer shapes) is not changed in this case. Final dimensioning is influenced by manufacturing considerations. On completion of the dimensioning work the dimensions are laid down and the strength analysis is carried out in a single computer run. The flow of the program is demonstrated in the example of the Airbus A 300 B rear fuselage. Author

**N74-15615** Chantiers de l'Atlantique, Saint Nazaire (France).  
**THE DOUBLE ITERATION METHOD IN STRUCTURAL OPTIMIZATION**  
Daniel H. Finitzer. In AGARD Second Symp. on Structural Optimization, Nov. 1973. 10 p. refs. (For availability see N74-15596 06-32)

Most structural optimization processes require a large number of iterations to be performed, involving at each step a detailed stress analysis of the current design. Considering that a gross analysis is comparatively very economical, it is possible to perform most iterations on a simplified mesh, with only occasional refined analyses to correct the mismodeling effects. Although the overall number of steps referred to as primary iterations necessary to achieve the optimum is then higher than by conventional procedures, only those involving a detailed analysis or secondary iterations are significant timewise. That double iteration scheme was employed in determining the minimum

weight design, assumed to be fully stressed, of a tanker web frame, using the stress ratio method. Satisfactory convergence was reached after 2 secondary iterations, whereas by standard calculations 8 to 10 would have normally been required. Author

**N74-15616** Technische Hochschule Aachen (West Germany). Inst. fuer Leichtbau.  
**HOMOLOGOUS DEFORMATION OF STIFFENED SHELLS FOR RADIO TELESCOPE STRUCTURES**  
J. F. Kowalewski and H. A. Ziebart. In AGARD Second Symp. on Structural Optimization, Nov. 1973. 13 p. refs. (For availability see N74-15596 06-32)

In radio telescopes all surface elements have to reflect incoming radio waves to a defined focus, i.e. the surface should be an exact paraboloid. As a telescope has to be tilted elastic deformations caused by rotating the telescope about a horizontal axis are inevitable. But these deformations should be homologous, i.e. should change only the position of the focus, the focal length and the axis of the paraboloid. The report deals with the homology conditions for the displacements and the rotations of the tangents of the surface and the change of the parameters of the paraboloid. It is shown how to find the optimum design of a reflector shell, which complies with these homology conditions. Author

**N74-15617** Technische Univ., Berlin (West Germany). Inst. of Aeronautics and Astronautics.  
**OPTIMIZATION OF THE LAYOUT OF TRUSSES COMBINING STRATEGIES BASED ON MICHELL'S THEOREM AND ON THE BIOLOGICAL PRINCIPLES OF EVOLUTION**  
A. Hoeller, U. Laysner, and J. Wiedeman. In AGARD Second Symp. on Structural Optimization, Nov. 1973. 8 p. refs. (For availability see N74-15596 06-32)

A method developed for finding the optimum layout of plane trusses is reviewed. Both strategies employed are described in some detail, giving special attention to the problem of selecting the proper set of points at the beginning of the optimization process. An example of the application of the evolution strategy is given. When both strategies are combined, having each one perform the function in the optimization process it is best suited for, their specific disadvantages can be eliminated. Thus an initial design is found using linear programming while the evolution strategy is used to find better positions of the joints. This constitutes one cycle of optimization. More cycles will follow if the improved positions of the joints require a change in the set of the optimum bars. The problem of a cantilever truss loaded at the tip is solved using the combined strategies. The optimum structure for this case being known, a comparison is made showing the efficiency of the method. Author

**N74-19560\*** Advisory Group for Aerospace Research and Development, Paris (France).  
**ACOUSTIC FATIGUE DESIGN DATA, PART 3**  
A. G. R. Thomson (Eng. Sci. Data Unit Ltd.) and R. F. Lamport (Eng. Sci. Data Unit Ltd.). Dec. 1973. 62 p. refs.  
(AGARDograph 162 Pt 3. AGARD AG 162 Pt 3. Avail. NTIS HC \$6.25)

The design criteria for aircraft structural elements to reduce the effects of acoustic fatigue are discussed. The subjects presented are: (1) endurance of titanium and titanium alloy structural elements subjected to simulated acoustic loading; (2) damping in acoustically excited structures; (3) reference frequency of panel with flexible stiffeners; and (4) estimation of stress in skin panels with flexible stiffeners subjected to random acoustic loading. Author

## 33 THERMODYNAMICS AND COMBUSTION

Includes ablation, cooling, heating, heat transfer, thermal balance, and other thermal effects, and combustion theory. For related information see also 12 Fluid Mechanics, and 27 Propellants

**N71-25358#** Advisory Group for Aerospace Research and Development, Paris (France)

### THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS: COOPERATIVE THERMAL EXPANSION MEASUREMENTS UP TO 1000 C. PROJECT SECTION 1A

E Fitzer Mar 1971 65 p refs

(AGARD-AR-31-71) Avail NTIS

Pushrod dilatometer measurements to 1000 C as carried out by employing samples having the same history were evaluated both statistically and with regard to the nature of the errors involved. Using high purity gold and platinum as selected reference materials, it was found that the relative pushrod dilatometer measurements when used in a group effort can yield an accuracy equal to that obtained by individual absolute measurements. This result was confirmed with engineering materials such as an austenitic alloy, a Ti-10 W alloy, sintered alumina and fine grain graphites.

Author

**N72-12950#** Advisory Group for Aerospace Research and Development, Paris (France). Propulsion and Energetics Panel

### HEAT TRANSFER IN ROCKET ENGINES

H Ziebland (Explosives Res and Develop Estab) and R C Parkinson (Rocket Propulsion Estab) Sep 1971 160 p refs

(AGARD-AG-148-71, AGARDograph 148) Avail NTIS

Basic heat transfer processes are considered: simple convective heat transfer from hot gases to the engine walls under various conditions, radiation heat transfer, and coolant heat transfer processes. Methods of cooling used in liquid propellant rocket engines, such as regenerative film ablation and radiation cooling are discussed. The properties of materials that must be known by the engine designer, from the transport properties of the hot combustion gases to those of the materials from which the engine will be constructed. Emphasis was placed on presenting simple methods for calculating the magnitude of heat transfer.

Author

**N72-18946#** Advisory Group for Aerospace Research and Development, Paris (France)

### HEAT EXCHANGERS

Jean J Ginoux, ed Jan 1972 97 p refs

(AGARD-LS-57) Avail NTIS

Problems associated with the design, testing and use of heat exchangers are discussed with respect to compact heat exchangers used in turbine regenerators and aerospace vehicles, heat exchangers in the process and power industries, and heat exchangers with liquid metals. For individual titles, see N72-18947 through N72-18949.

**N72-18947#** Stanford Univ., Calif.  
**COMPACT HEAT EXCHANGERS**

William M Kays In AGARD Heat Exchangers Jan 1972 22 p refs (See N72-18946 09-33)

Avail NTIS

The design and application of heat exchangers employing surface arrangements having the characteristics of very large amounts of surface heat transfer area per unit of volume are considered. Relationships between the friction power expended and the heat transferred are explored, and methods of improving the performance of heat exchanger surfaces are investigated. Heat exchanger design theory, to the extent that it is applicable

to very compact exchangers, is reviewed. Data are presented on the heat transfer and friction behavior of a number of very compact surfaces.

Author

**N72-18948#** European Atomic Energy Community, Ispra (Italy). Technology Div

### HEAT EXCHANGE AND HEAT EXCHANGERS WITH LIQUID METALS

R Nijssing In AGARD Heat Exchangers Jan 1972 61 p refs (See N72-18946 09-33)

Avail NTIS

Forced convection, liquid metal heat transfer is discussed. The physical principles underlying single phase, liquid metal heat transfer theory is outlined, and the significant developments of the past decade are described. Flow and heat transfer aspects associated with uniform channels (tubes, parallel plates, annuli) are considered first. This provides the ground for a basic discussion of flow and heat transfer in rod bundle geometries and of topics of engineering interest including thermal design of liquid metal cooled nuclear fuel rod assemblies and thermal analysis of liquid metal heat exchangers. Emphasis throughout is on a basic approach. In theoretical considerations particular attention is paid to turbulent transport characteristics in the coolant and to the methodology underlying heat transfer computation procedures.

Author

**N72-18949#** National Engineering Lab., East Kilbride (Scotland). **INDUSTRIAL HEAT EXCHANGERS**

D Christl W Drummond (Babcock and Wilcox Ltd, London), and I Murray In AGARD Heat Exchangers Jan 1972 9 p refs (See N72-18946 09-33)

Avail NTIS

Various types of heat exchangers used in the process industries are considered. Specifically the design of the following heat exchangers are discussed: shell-and-tube heat exchangers, condensers, evaporators and reboilers, plate heat exchangers, air coolers, cooling towers, evaporative coolers, and direct contact heat exchangers.

Author

**N72-24959#** Advisory Group for Aerospace Research and Development, Paris (France)

### ABLATION

H Hurwicz, K M Kratsch, J E Rogan, and R E Wilson, ed. (NOL White Oak Md) Mar 1972 55 p refs

(AGARD-AG-161) Avail NTIS HC \$4.75

Physico-mathematical approaches to analysis of ablation processes are brought out, ranging from a simplistic heat of ablation concept to the sophisticated analysis of laminar and turbulent flow, nonequilibrium ablation in chemically reacting flow fields, including surface reactions, and radiative heat transfer. Emphasis is given to the synergistic mechanisms occurring during ablation. Examples of nosetip interaction with the aero-thermodynamic environment at the surface and at depth are given, and striation phenomena on the afterbody are discussed. Material property and environmental effects on material performance are also reviewed, as well as the test simulation requirements. Requirements for further studies of mechanical erosion, other synergistic effects, and extension of facilities range of performance are also noted.

Author

**N72-24960#** Advisory Group for Aerospace Research and Development, Paris (France)

### THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS. PROJECT SECTION 1B. THERMAL EXPANSION MEASUREMENTS FROM 1000 C TO 2600 C

E Fitzer Feb 1972 60 p refs

(AGARD-AR-38) Avail NTIS HC \$5.00

The thermal expansion behavior of selected materials above 1000 C was determined experimentally. Pure platinum, sintered Al<sub>2</sub>O<sub>3</sub>, sintered and arc cast tungsten, Ta-10W alloy, and three types of polycrystalline graphites (AXM 50, RVD, AAQ1), each

from the same original stock, were used as sample materials. Several experimental techniques, such as twin microscopic measurements, push rod methods and X-ray studies were applied. All experimental results were analyzed for the possible error causes, and conclusions were drawn with respect to the accuracy of experimental data obtained by the different methods, as well as for the suitability of the sample materials for such measurements. Author

**N73-20945#** Advisory Group for Aerospace Research and Development, Paris (France)

**HEAT-TRANSFER MEASUREMENTS IN SHORT-DURATION  
HYPERSONIC FACILITIES**

D. L. Schultz (Oxford Univ.) and T. V. Jones (Oxford Univ.) Feb 1973 155 p refs

(AGARD-AG-165, AGARDograph-165) Avail NTIS HC \$9.75

The techniques for making measurements of heat transfer in short duration and rapidly varying flows are reviewed. Methods discussed include: gauges operating on the semi-infinite principle, calorimeter gauges, pyroelectric heat transfer gauges, measurement of radiative heat transfer, and optical methods. The error in deduced heat transfer rate arising from a surface temperature discontinuity due to the presence of an isolated heat transfer gauge is also discussed. FOS

**N73-26968#** Advisory Group for Aerospace Research and Development, Paris (France)

**THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS.  
PROJECT SECTION 2: COOPERATIVE MEASUREMENTS  
ON HEAT TRANSPORT PHENOMENA OF SOLID MATERIALS  
AT HIGH TEMPERATURE**

E. Fitzer (Karlsruhe Univ., West Germany) Mar 1973 113 p refs

(AGARD-R-606, AGARD-606) Avail NTIS HC \$7.75

Measurements of heat transfer properties of solid materials at high temperatures are discussed. The range between 1,000 C and 3,000 C is examined. It is stated that exact information on the thermophysical properties of materials and on the temperature dependence must be considered as a precondition for the calculation of the behavior of structural elements during service, especially with respect to transient heating and cooling. Mathematical models are provided to quantify the heat loss characteristics. Specific materials are analyzed to determine their thermodynamic properties. Author

## 34 GENERAL

Includes information of a broad nature related to industrial applications and technology, and to basic research, defense aspects, information retrieval, management, law and related legal matters, and legislative hearings and documents.

**N71-23501#** Advisory Group for Aerospace Research and Development Paris (France)

**SCIENTIFIC AND TECHNICAL INFORMATION: WHY, WHICH, WHERE, AND HOW?** Lecture Series

Feb 1971 65 p refs. Conf. Presented in Oslo 2-3 Nov 1970, sponsored by the Tech. Inform. Panel and the Consultant and Exchange Programme of AGARD. Also Presented in Rome 5-6 Nov 1970.

AGARD-LS-44. Avail. NTIS

### CONTENTS

1. INTRODUCTORY PAPER. H. A. Stolk (Natl. Aerospace Lab., Amsterdam, Netherlands) 3 p. refs. (See N71-23502 12-34)

2. WHAT CAN INFORMATION DO FOR YOU? A. M. Ironside (Defence Sci. Inform. Serv., Ottawa, Ontario) 7 p. refs. (See N71-23503 12-34)

3. USER NEEDS. J. F. Stearns (NASA, Washington, D.C.) 6 p. (See N71-23504 12-34)

4. SOURCES OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION. H. A. Stolk (Natl. Aerospace Lab., Amsterdam, Neth.) 13 p. refs. (See N71-23505 12-34)

5. SELECTIVE DISSEMINATION OF INFORMATION: A SYSTEM REVIEW. S. C. Schuler (Min. of Technol., Orpington, Engl.) 22 p. refs. (See N71-23506 12-05)

6. CONCEPT, MISSION, AND OPERATION OF SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS. G. S. Simpson, Jr. and J. W. Murdock (Battelle Mem. Inst., Columbus, Ohio) 14 p. (See N71-23507 12-34)

**N71-23502#** National Aerospace Lab., Amsterdam (Netherlands) **INTRODUCTORY PAPER**

H. A. Stolk. In AGARD Sci. and Tech. Inform. Feb 1971 3 p. refs. (See N71-23501 12-34)

Avail. NTIS

Information systems, and their histories, are briefly discussed along with subjects to be covered in the current lecture series. In this series the product considered was the technological information that exists in the form of printed words, graphs, tables, pictures, specifications, etc., and means by which this information can be transferred. Also discussed in the introductory speech is the transfer of technology and its management. A. L.

**N71-23503#** Defence Scientific Information Service, Ottawa (Ontario)

**WHAT CAN INFORMATION DO FOR YOU?**

Alice M. Ironside. In AGARD Sci. and Tech. Inform. Feb 1971 7 p. refs. (See N71-23501 12-34)

Avail. NTIS

A philosophical, non-technical approach is used to demonstrate that information is both an inherent part of life and a part of the fabric of living, and that information is being presented to the individual continuously throughout his life, by his own senses, by other people, and by the various media of communication. Also, that this information may be unheeded or heeded, and stored in his memory, or may be stored in suitable forms by mechanical, electronic, and other means. Once stored, it may be later retrieved and applied to any appropriate purpose. Information is increasingly being recognized as a prime resource, and the problems of maintaining the store of this resource and of its exploitation are being recognized and solutions sought. Author

**N71-23504#** National Aeronautics and Space Administration, Washington, D.C.

**USER NEEDS**

John F. Stearns. In AGARD Sci. and Tech. Inform. Feb 1971 6 p. (See N71-23501 12-34)

(NASA-TM-X-67142) Avail. NTIS CSCL 05B

The question of user needs is examined from three viewpoints: what has been and is being done to determine actual user needs; the kinds of services now evolving to satisfy these needs; and possible further steps to improve both definition and satisfaction of these needs. Attention is given to general areas of bibliographic services, and to specific opportunities inherent in these services for the application of techniques and procedures that may provide potential users with easier access to a wider range of informational alternatives.

Author

**N71-23505#** National Aerospace Lab., Amsterdam (Netherlands) **SOURCES OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION**

H. A. Stolk. In AGARD Sci. and Tech. Inform. Feb 1971 13 p. refs. (See N71-23501 12-34)

Avail. NTIS

Attention is paid to the information environment, the information explosion, and the user and his behavior. Informal channels and formal services for obtaining information are discussed. A short description is also given of the problems in information retrieval.

Author

**N71-23506#** Ministry of Technology, Orpington (England) **Reports Centre for Science and Technology**

**SELECTIVE DISSEMINATION OF INFORMATION: A SYSTEM REVIEW**

S. C. Schuler. In AGARD Sci. and Tech. Inform. Feb 1971 22 p. refs. (See N71-23501 12-34)

Copyright. Avail. NTIS

Selectivity is an essential factor in the transfer of information and the Selective Dissemination of Information (SDI) is a technique for providing individual users or groups of users with announcements of a limited number of documents specifically of interest to them. For large systems, selection of relevant documents is achieved by a computer program which compares a file of bibliographic data on current reports, journals, articles, etc., with the interest profile of the SDI user. The selected references can be provided to the user in card form, useful for filing, or as a computer-printed listing containing the main document bibliographic data, descriptor terms, and, in some cases, a short abstract. A review was made of various automated systems which have developed in North America and Europe during recent years. Some experiences of both large and small SDI systems are discussed and detailed aspects, such as profile construction, cost, benefits, and economics, and user surveys, are considered. An alternative to printed output, an outline is given of a system using on-line access to a central information store, enabling the user to have selected references displayed visually at his remote console. Author

**N71-23507#** Battelle Memorial Inst., Columbus, Ohio **CONCEPT, MISSION, AND OPERATION OF SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS**

G. S. Simpson, Jr. and J. W. Murdock. In AGARD Sci. and Tech. Inform. Feb 1971 14 p. (See N71-23501 12-34)

Avail. NTIS

Information Analysis Centers (IACs) are discussed in three parts: concept, mission, and operation. Since there is an array of existing scientific and technical information services, varying from the conventional library, through special libraries and document depositories to IACs, the presentation considers what an IAC is, how it relates to other information services, and its fundamental concept. The mission of an IAC is considered in the light of its users, or peer group, how unpublished information is obtained and used, and

how feedback helps the IAC achieve its mission. Two non-government supported IAC are described along with one government center. Also considered are operational aspects (administration and management) of an IAC. Based on close contact with over a dozen operating IACs, actual experiences pertaining to the recruitment and utilization of competent research scientists and engineers in information analysis work, advantages of working in an IAC environment, key problems in day-to-day operation, and the ever present problem of money are discussed. Author

**N71-36382/** Advisory Group for Aerospace Research and Development, Paris (France). Structures and Materials Panel. **DIRECTORY OF ORGANIZATIONS, INVESTIGATORS, AND PROGRAMS IN HIGH TEMPERATURE CORROSION RESEARCH**

Aug. 1971. 26 p.  
(AGARD-R-586-71) Avail. NTIS

Organizations are listed together with investigators and specific research areas in the field of high temperature corrosion. The list includes 178 organizations from eleven NATO countries and Spain. A category index indicates the area in which the various organizations are conducting research. Two areas receiving the most attention are material behavior under corrosion and reaction kinetics and diffusion processes. Author

**N73-15968x** Advisory Group for Aerospace Research and Development, Paris (France)

**THE VON KARMAN LECTURE LESSONS LEARNED AND FUTURE DIRECTIONS IN THE MANAGEMENT OF TECHNICAL PROGRAMS**

Robert C. Seamans. Sep. 1972. 36 p. Lecture held at Brussels, 28 Sep. 1970.

Avail. NTIS. HC \$4.00

Advances in technology management, learned at NASA and DOD, are briefly reviewed. The NASA programs involved feedback from the customer, accurate assessment and control using detailed schedules of tasks and costs, and a three-way balance between performance, schedule, and cost. The defense management aided the condition that new systems must also be produced and operated in large numbers. Illustrations are given using major new weapon, aircraft systems. Competitive prototyping and future directions in military programs are described along with the application of aerospace technology to civil needs. It is concluded that NATO countries must look for better ways to provide effective defense forces and meet growing civil needs. Improved technology management is of critical importance, and prototype programs must be carefully selected with a minimum of duplication. Papers on the challenge facing NATO, the future of defense cooperation among NATO nations, and technical cooperation among NATO nations are appended. NEN

**N73-19959x** Advisory Group for Aerospace Research and Development, Paris (France)

**AIR TO GROUND TARGET ACQUISITION**

Nov. 1972. 170 p. refs. Presented at AGARD Aerospace Med. Panel Specialist Meeting, Brussels, Belgium, 31 May - 1 Jun. 1972.

(AGARD-CP-100) Avail. NTIS. HC \$10.50

The fifteen papers and ensuing discussions presented at the AGARD Aerospace Medical Panel Specialist Meeting on Air to Ground Target Acquisition held in Brussels, Belgium, on the 31st May and 1st June 1972 are reported. The papers cover theoretical and practical aspects of visual search and detection including the effects of complex backgrounds, illumination and contrast, and the application of mathematical modeling techniques to the solution of target acquisition problems. For individual titles, see N73-19960 through N73-19974.

**N73-19980** North American Rockwell Corp., Anaheim, Calif.

**THE LIKELIHOOD OF LOOKING AT A TARGET**

Charles P. Greening. In AGARD Air to Ground Target Acquisition. Nov. 1972. 8 p. (For availability see N73-19959 10-34)

Visual search behavior is characterized by brief glimpses of the terrain, separated by rapid eye movements, or saccades. The likelihood of looking at a target with any particular glimpse is, in most models of search behavior, assumed to result from either random motion or a mechanically systematic search pattern. In the present study, it is assumed that the observer uses extra-foveal vision to evaluate the terrain before each saccade, to maximize the likelihood of looking at the target. Quantitative data on extra-foveal search, obtained in a different context by Williams, show that such behavior is lawful and predictable. The results are here applied to dynamic air-to-ground yielding target acquisition predictions which compare favorably with those obtained by other methods. Author

**N73-19961** British Aircraft Corp. (Operating) Ltd., Bristol (England). Guided Weapons Div.

**MODELING OF RANDOM HUMAN VISUAL SEARCH PERFORMANCE BASED ON THE PHYSICAL PROPERTIES OF THE EYE**

Ian Overington. In AGARD Air to Ground Target Acquisition. Nov. 1972. 12 p. refs. (For availability see N73-19959 10-34)

The physical properties of the eye lens and retina together with the involuntary eye movements (tremor and drift) are considered as the basic factors defining single glimpse detection probability. Introduction of the concept of convolution of object profiles with the spread function of the eye lens which allows extension of such single glimpse predictions to unsharp objects is discussed along with the effects of atmospheric attenuation and range dependency of subtended size. Using this comprehensive formula for single glimpse probability as an input a cumulative search probability model is developed for random search which takes account of search field of view, visual lobe effects and the transition from single glimpse to multiple glimpse situation at any part of the field of view. Author

**N73-19962** British Aircraft Corp. (Operating) Ltd., Bristol (England). Guided Weapons Div.

**THE K FACTOR IN AIR-TO-GROUND ACQUISITION MODELLING**

D. G. Silvanthorn. In AGARD Air to Ground Target Acquisition. Nov. 1972. 14 p. refs. (For availability see N73-19959 10-34)

This paper illustrates that correspondence obtained between the shape of the probability-range curves is good both for field and simulated field detection data, but that actual performance levels are much lower than predicted. A degradation factor (the K factor) has been introduced to cover this discrepancy and a similar fudge factor has been invoked to cover differences between simulated and direct field trial data. The paper examines the factors on which K is dependent and describes relevant experiments and the associated attempts at modelling them. It is at once a progress statement and an indication of the necessary further studies. Author

**N73-19963** Nottingham Univ. (England). Dept. of Psychology. **CALCULATION AND SIMULATION OF THE EFFECTS OF TWO COMPLEX SEARCH SITUATIONS**

C. I. Howarth, J. R. Bloomfield, and M. E. Dewey. In AGARD Air to Ground Target Acquisition. Nov. 1972. 12 p. refs. (For availability see N73-19959 10-34)

Two attempts were made to elucidate complex search situations. In the first, using Howarth and Bloomfield's theoretical work as a basis, calculations were made of the cumulative search time data likely to occur when a target that was an extreme example of a distribution of objects was presented among a sample of these objects. The calculations covered variations in (1) the target-non-target cut-off point, (2) the size of the visual lobe area associated with the target, and (3) the response time that was necessary after a target was located. The second, a simulation study making use of the Monte Carlo method, treated a situation in which a number of targets were presented among many non-target objects. A single target, which had a small visual lobe area associated with it, was presented with a variable number of targets with large visual lobe areas. The size of the visual lobe areas associated with the two kinds of target was varied, as were the number of the large lobe area targets and the length of the response times necessary after a target had been

located. The likely effect of these variations on the time needed to locate the single target is reported. In general, more time was needed the smaller the lobe area of the single target is reported. In general, more time was needed the smaller the lobe area of the single target, the greater the lobe area of the large lobe targets, the greater the number of the latter present, and the longer the response times. The cumulative curves obtained changed in shape as the four variables altered in these directions. The change in shape is likely to be found with human observers who adopt the most suitable strategy for locating the small lobe area target. Author

**N73-19964** British Aircraft Corp (Operating) Ltd, Bristol (England): Guided Weapons Div  
**THE EFFECT OF COMPLEX BACKGROUNDS ON ACQUISITION PERFORMANCE**

M. B. Brown. In AGARD Air to Ground Target Acquisition Nov 1972. 6 p. refs (For availability see N73-19959 10-34)

The relationship between the subjective effect of structured target backgrounds on acquisition performance and physical attributes of the scene luminance structure was investigated both theoretically and experimentally. The theoretical attempts are described to classify various aspects of complexity, and an experiment was carried out using synthetic target material. The results showed that certain targets are more easily recognized than others for all the complex backgrounds used, and also indicated that recognition may be regarded as the detection of detail. A large variability between subjects was observed. Part of this variation can be attributed to eyesight differences and to experience. Author

**N73-19966** Nottingham Univ (England): Dept of Psychology  
**PERIPHERAL ACUITY WITH COMPLEX STIMULI AT TWO VIEWING DISTANCES**

J. R. Bloomfield. In AGARD Air to Ground Target Acquisition Nov 1972. 10 p. refs (For availability see N73-19959 10-34)

Visual acuity is defined in terms of the minimum resolvable visual angle or its reciprocal. This assumes, implicitly, that acuity is independent of viewing distance. In the current study, this assumption was tested for peripheral acuity using two viewing distances. A complex visual display was used for the acuity task. The display contained a regular 17 by 10 arrangement of discs. The display was exposed for 0.25 seconds, with the observer fixating a particular point in it. Measurements were made of the threshold distance from the fixation point at which a single, smaller target disc could be detected. The data, obtained from eight observers, supported the assumption that peripheral acuity is independent of viewing distance, the threshold distance remaining unchanged for four sizes of target, in spite of the large change in viewing distance. This implies that performance in air-to-ground target acquisition should not be directly affected by variations in viewing distance. Author

**N73-19968** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)

**A MODEL FOR THE INHERENT CONTRAST CONDITIONS IN FULL-FORM OBJECTS**

Max R. Nagel. In AGARD Air to Ground Target Acquisition Nov 1972. 21 p. refs (For availability see N73-19959 10-34)

The concept was developed of a simple model that is representative of the luminance and contrast conditions on full-form objects. A reasonably realistic approach is a sphere that is exposed to the irradiation from the entire sky, the sun, and the ground, taking into account the considerable variation of the luminance in the sky based primarily on measurements of the sky luminance in the Pikes Peak region of Colorado, U.S.A., calculations were made of the inherent contrast in such a model when it is viewed from any direction with fields of view of various sizes. Other calculations were concerned with the model object's contour contrast against its background and with its color. Representative results of these calculations are shown and discussed. Author

**N73-19967** Scripps Institution of Oceanography, San Diego, Calif.: Visibility Lab

**AIR-TO-GROUND VISIBILITY OF LIGHTS AT LOW BACKGROUND LEVELS**

John H. Taylor. In AGARD Air to Ground Target Acquisition Nov 1972. 8 p. refs (For availability see N73-19959 10-34)

After sunset and before sunrise the visual task of the airborne observer becomes radically different from that which he must perform during the daylight hours. The range at which targets will be seen depends upon the physical properties of the source, such as its intensity and color, the length of time for which it is exposed to view, the transmissivity of the atmospheric path of sight, and the visual performance capabilities of the observer. This paper describes some new data which apply to this problem, and suggests that the relationship between visibility and flash duration may be somewhat more complex than has usually been assumed. The results have application to both aggressive and defensive needs, and are of interest to the signalling community in general. Author

**N73-19968** Air Force Systems Command, Wright-Patterson AFB, Ohio: Flight Environments Branch

**AIR-TO-GROUND TARGET ACQUISITION WITH FLARE ILLUMINATION**

Robert L. Hilgendorf. In AGARD Air to Ground Target Acquisition Nov 1972. 11 p. refs (For availability see N73-19959 10-34)

This paper is concerned with the results from three recent experiments. Experiment 1 dealt with the effect of shielding a 25,000,000-lumen flare source and determining the optimal number of flares to be used for a given target area. No statistically significant effect was found due to flare shielding. For the given target area simulated, it appeared that there was no additional benefit derived from igniting more than two flares over a simulated area of about 1.5 kilometers by 5 kilometers. Experiment 2 dealt with shielding of a 60,000,000 lumen source, and again, no statistically significant effect was found due to the flare shielding. Experiment 3 dealt with the visual acuity under simulated flare light. In this experiment each of eight groups of five subjects performed simulated observer altitude ranging in 152 meter increments from 152 to 1,219 meters. For the slant ranges simulated (1,029 to 1,587 meters), 610 meters was the best altitude for visual performance. Like the other findings, this could have significant impact on tactical planning for night missions. The parameters of this study have now been blown-up to real-world size and the Aerospace Medical Research Laboratory, in conjunction with the Air Force Armament Laboratory, is conducting flight tests to validate the altitude data of the experimental simulations. Author

**N73-19969** Army Aeromedical Research Lab, Fort Rucker, Ala  
**AIR TO GROUND TARGET ACQUISITION**

Robert W. Bailey. In AGARD Air to Ground Target Acquisition Nov 1972. 5 p. refs (For availability see N73-19959 10-34)

Biomedical problems with the helmet mounted sight and visual target acquisition system are discussed in terms of sighting errors in the laboratory and in flight for still and moving targets. The effects of this type optical device on depth and spatial perception are presented along with suggested bioengineering techniques for improving the system. F O S

**N73-19970** Army Electronics Command, Fort Monmouth, N.J. Avionics Lab

**A DESIGN CONCEPT FOR A DUAL HELICOPTER NIGHT SCOUT SYSTEM**

William J. Kenneally. In AGARD Air to Ground Target Acquisition Nov 1972. 11 p. refs (For availability see N73-19959 10-34)

Limited but promising operational experience with helicopter-borne night vision systems (both low light level TV and forward looking infrared) has spurred an interest in the application of night vision technology to second generation airborne systems. The limited quantitative performance data on these first generation systems, coupled with the significant advances in night vision technology made during the intervening period, place several

restrictions on the system designer attempting to make logical system tradeoffs. The scope of the paper is to examine various relevant data on the subject and to develop a design concept for such a second generation scout system. Author

**N73-19971** Aeronautical Systems Div., Wright-Patterson AFB, Ohio

**REALISTIC CONSIDERATIONS OF TARGET ACQUISITION ON LINES OF COMMUNICATIONS**

Roy K. Frick, Diane E. Summers, and Thomas E. Tyson. In AGARD Air to Ground Target Acquisition. Nov 1972. 10 p refs (For availability see N73-19959 10-34)

An approach is presented to determining the probability of acquiring targets by a search aircraft which flies along an enemy line of communication (LOC). A line of communication is defined as a route, e.g., a road, waterway, or railroad, and the targets of interest are trucks, boats, or other appropriate carriers. The analysis approach consists of three areas of investigation: (1) analyzing the contour (twists and turns) of a route for purposes of establishing a preferred flight path plus determining the frequency distributions of LOC aspects relative to this flight path; (2) computing the probability of detecting a target, given a set of LOC, target, and flight path conditions; and (3) integrating the results of the first two areas of investigation to produce the probability of target acquisition for the overall set of conditions. The methodology presented can be applied to investigate conditions of target acquisition for existing lines of communication in the real world. Author

**N73-19972** University of Technology, Leicester (England). Dept. of Ergonomics and Cybernetics

**THE EFFECTS OF BRIEFING ON TELEVISUAL TARGET ACQUISITION**

K. R. Parkes. In AGARD Air to Ground Target Acquisition. Nov 1972. 9 p refs (For availability see N73-19959 10-34)

Evidence from a number of studies indicates that the nature of the briefing information available to the observer has a marked effect on target acquisition performance. Low-level forward oblique photographs of the target and surrounding terrain have been found to be a particularly effective form of briefing information, but such photographs may not always be available. In the experiment reported, an evaluation was made of the extent to which, in the absence of suitable oblique photographs, perspective representations of the target and surrounding terrain, derived from maps, facilitated televisual target acquisition performance. The effectiveness of these perspective views, used as briefing material in addition to maps, was compared with that of maps used alone, and maps used together with oblique photographs. The results show that, while not as effective as oblique photographs, the perspective views brought about some improvement in performance as compared with the maps alone. Author

**N73-19973** British Aircraft Corp. (Operating) Ltd., Bristol (England). Guided Weapons Div.

**THE USE OF KELLY'S REPERTORY GRID TECHNIQUE FOR ASSESSING SUBJECTIVE ESTIMATES OF IMPORTANT PARAMETERS FOR TARGET ACQUISITION**

A. J. Mitchell. In AGARD Air to Ground Target Acquisition. Nov 1972. 12 p refs (For availability see N73-19959 10-34)

Kelly's Repertory Grid Technique was employed to study the area of subjective factors involved in visual acquisition of targets, in the hope of covering the discrepancy between the data obtained from psychophysical studies and actual field data. Two experiments were conducted using highly trained aircrew which have led to the definition of some subjective parameters and estimates of their importance. Through analysis three major overlying components were elicited. These major components were: (1) The target has visual prominence against the background; (2) The target is in a helpful built-up environment, or Target is in an urban environment; (3) There are geographical and map identification features around the target to aid acquisition. Author

**N73-19974** British Aircraft Corp. (Operating) Ltd., Bristol (England). Guided Weapons Div.

**SOME PSYCHOMETRICS IN RELATION TO TARGET ACQUISITION**

Sandra J. Seale. In AGARD Air to Ground Target Acquisition. Nov. 1972. 7 p refs (For availability see N73-19959 10-34)

The variance associated with acquisition performance arises from between subject differences and within subjects differences. A recent intensive study was conducted, using a pattern discrimination test, the Witkin Embedded Figures Test (EFT). Previous experimental work using this test indicated that it would be suitable for the target acquisition situation in that it would estimate analytical ability, which was hypothesized as being a factor contributing to the variation in acquisition performance. Although no overall significance was found between EFT scores and measures of acquisition performance under various briefing conditions, the study highlighted the difficulties involved in using psychometric tests in the context of target acquisition. The paper examines these difficulties and illustrates the contribution to the methodology in this area. Author

**N73-20959** Advisory Group for Aerospace Research and Development, Paris (France)

**AGARD GERMAN COOPERATION**

Frank Wattendorf. In DFVLR Management in Sci. and Technol. Sep 1971. p 80-87 (For availability see N73-20955 11-34)

Dr. Theodor Benecke's activities and accomplishments as Chairman of the Advisory Group for Aerospace Research and Development at AGARD. NATO are described. Typical cooperation projects for mutual benefit constituted development of V-STOL aircraft, low altitude defense. Transall, G 91, F 104 G, and the German-French Research Institute at St. Louis, France. G G

**N73-21881\*** Advisory Group for Aerospace Research and Development, Paris (France)

**THE 1972 AGARD ANNUAL MEETING COMMEMORATING AGARD'S TWENTIETH ANNIVERSARY**

28 Sep 1972. 112 p. In FRENCH and ENGLISH. Meeting held at Brussels. 28 Sep 1972. Avail. NTIS HC \$7.75

Proceedings of the AGARD meeting are reported. Belgian research and development programs presented include some Belgian contributions to aerospace techniques, structures and materials research in Belgium, and fluid dynamic research in Belgium. A lecture on lessons learned and future directions in the management of technical programs was also presented. F.O.S.

**N74-17664\*** Advisory Group for Aerospace Research and Development, Paris (France)

**DIRECTORY OF RESEARCH ACTIVITIES ON IN-SITU COMPOSITES**

Oct 1973. 21 p refs. Prepared by Battelle Columbus Labs. IAGARD-R-6091. Avail. NTIS HC \$3.25

A directory of research facilities, laboratories, and corporations conducting research on composite materials is presented. The organizations are identified by the country in which located and the principal respondents are identified. A brief statement concerning the type of research being conducted accompanies each entry where applicable. Author

**N74-21610\*** Advisory Group for Aerospace Research and Development, Paris (France)

**AGARD ANNUAL MEETING, 1973**

Dec 1973. 68 p refs. In ENGLISH, partly in FRENCH. Conf. held at Athens. 13 Sep 1973. Avail. NTIS HC \$6.50

Conference papers are presented which relate to: (1) research and development activities in Greece; and (2) the use of science and technology to meet military requirements at reduced costs. For individual titles see N74-21611 through N74-21618.

**N74-21611** Advisory Group for Aerospace Research and Development, Paris (France)

**RESEARCH AND DEVELOPMENT ACTIVITIES IN GREECE**  
S. N. Moraitis (Hellenic Air Force) *In its* AGARD Ann Meeting, 1973 Dec 1973 p 8-13 (For availability see N74-21610 12-34)

An overview is presented of the distribution of research efforts in Greece according to the areas of activity and expenditures. Tables are given which illustrate the following: (1) the activities which contributed to the formation of the national income for the years 1970 through 1972, and secondly the forecasts for 1987; (2) the country's gross domestic asset formation per field of productive activity; (3) electric power exploitation as achieved by the Public Power Corporation; (4) the structure of domestic asset formation in the industrial enterprises for four categories of products; (5) distribution of expenditures for types of research and the percent of the gross national product represented by the total research expenditure; and (6) the financing of research and development according to the performing agency for the current five year program which runs from 1973 to 1977.

D L G

**N74-21612** Athens Univ. (Greece)

**ELECTRONICS AND SPACE ACTIVITIES IN GREECE**

K. Anastasiades *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 14-17. In ENGLISH and FRENCH (For availability see N74-21610 12-34)

The role of electronics and space activities in scientific research is discussed. Emphasis is placed on a study of wave propagation conditions between two points in magnetic conjunction, Athens and Salisbury, Rhodesia. Some results are presented which were obtained in a special space research program to study the overall electron content simultaneously between the two points. The results were observed during the solar eclipse of 30 June 1973.

D L G

**N74-21613** Societe Nationale Industrielle Aerospatiale, Paris (France)

**TECHNIQUES ORIENTED TOWARDS COST REDUCTION**

M. Chevalier *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 22-27. In ENGLISH and FRENCH (For availability see N74-21610 12-34)

It is pointed out that parallel to the continuous improvement in performance regarding aircraft construction, actions are currently being developed towards simpler materials, open to quantity production, and characterized by a determined tendency towards economy. Three aspects are dealt with concerning the vehicle production: (1) structure; (2) power plants; and (3) equipment.

Author

**N74-21614** National Aerospace Lab., Amsterdam (Netherlands)

**TECHNICAL AND OPERATIONAL ASPECTS OF EXTERNALLY MOUNTED AIRCRAFT EQUIPMENT**

T. Van Oosterom *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 29-34 (For availability see N74-21610 12-34)

It is pointed out that the installation of additional equipment in an aircraft is often impossible due to space limitations. Consideration is given the choice which must be made between redesigning or modifying the fuselage or housing the equipment in an external speedpack or pod. Several advantages of a pod mounted system are indicated and specific design aspects which may require advanced applications of science and technology are discussed. It is concluded that the pod concept has the potential to solve in many cases, the problems inherent in the implementation of new operational equipment within the inventory of an air force. It is also concluded that for many applications the pod concept will have a superior operational cost effectiveness in comparison with an aircraft integrated system.

Author

**N74-21615** Ministry of Defence, London (England)

**THE REDUCTION OF AIRFRAME COSTS WITH PARTICULAR REFERENCE TO COMBAT AIRCRAFT**

J. Seddon *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 34-39 (For availability see N74-21610 12-34)

It is stated that for modern aircraft weapon systems such as a multi-role combat aircraft, cost reduction can be achieved at all stages of the procurement process, and by a wide variety of means. Some examples are presented of recent achievements in the following three phases: aerodynamic and structural design, mechanical and physical engineering, and manufacturing technology.

Author

**N74-21616** Ministry of Defence (West Germany)

**THE HINGELESS ROTOR: A CONCEPT TO INCREASE MISSION EFFECTIVENESS AT REDUCED COSTS**

P. Barth *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 40-50 refs (For availability see N74-21610 12-34)

The mechanical simplification of helicopters by elimination of blade attachment hinges is discussed. Emphasis is placed on the Bolkow system which features fiberglass rotor blades of high elasticity rigidly attached to a stiff hub. The stated advantages of the system are: (1) The hingeless rotor design needs only about 30 percent of the parts of an articulated rotor; (2) Control becomes more powerful, faster and more direct, and nearly independent of thrust; (3) The rotor blades can offer more than 10,000 hours of service life compared to 1,000 to 2,000 hours for comparable helicopters; (4) The fiberglass material is corrosion proof and tests have shown that it is insensitive to notches; (5) The hingeless rotor is most promising in fulfilling modern military requirements for air mobility.

D L G

**N74-21617** Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France)

**RESEARCH WORK AND COSTS, THE ROLE OF DATA PROCESSING**

P. Bohn *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 51-53. In ENGLISH and FRENCH (For availability see N74-21610 12-34)

An overview is presented on research work and costs in aircraft manufacturing with emphasis placed on the changes which have taken place as a result of the introduction of powerful computers. It is pointed out that computers provide a means to improve the modelling of physical phenomena and to demonstrate the resulting effects on the whole aircraft. Aircraft manufacturers are now in a position to achieve trade-offs which were at one time inconceivable, especially as far as costs are concerned. It is predicted that in the future, research work will require more highly trained engineers, extremely powerful computers, and very bulky data files. These requirements are based on: (1) In-flight development time is becoming increasingly short, and is devoted more and more either to the development of electronic systems, or to the analysis of abnormal flight patterns or failure investigations; (2) Official agencies and industrial firms everywhere must more and more frequently accept contracts for the development of prototypes; (3) Optimization, obtained by computers, permits the manufacturer to simplify without incurring any penalties as regards the objectives.

D L G

**N74-21618** Air Force Systems Command, Wright-Patterson AFB, Ohio

**IMPACT OF TECHNOLOGY ON COST REDUCTION**

John F. Brooke *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 53-60 (For availability see N74-21610 12-34)

The results are discussed of a United States Air Force survey conducted to identify those technologies which hold the greatest promise of reducing life cycle costs. The analysis indicates that the cost reducing aspects of seventeen identified technologies could achieve a ten year life cycle savings on the order of \$450 million. Five of these technologies, considered to be representative examples, are discussed in detail and include: (1) advanced composites; (2) weldbond joining; (3) metal working and munitions; (4) replaceable tread tire concept; and (5) aircraft battery technology.

D L G

**N74-274924** Advisory Group for Aerospace Research and Development, Paris (France)

**DIRECTOR'S ANNUAL REPORT, 1970, TO THE NATO MILITARY COMMITTEE**

Apr 1971, 80 p  
Avail NTIS HC \$7.00



A summary of AGARD's 1970 technical program is presented. Meetings, publications, personnel, and budgeting for this reporting period are discussed. Author

**N74-23493#** Advisory Group for Aerospace Research and Development, Paris (France)

**THE AGARD CHARTER**

1 May 1971. 17 p. In ENGLISH and FRENCH

Avail NTIS HC \$4.00

The charter, as authorized by the North Atlantic Military Committee document dated 5 April 1971, is presented in the original English version and in its French Translation. D L G

**N74-23494#** Advisory Group for Aerospace Research and Development, Paris (France)

**THE 1971 AGARD ANNUAL MEETING**

Dec 1971. 78 p. Meeting held at Nord-Torpa, Norway. 8 Sep 1971

Avail NTIS HC \$7.00

The conference held in Nord-Torpa, Norway, 8 September 1971 is reported. The theme of the First Plenary Session was Norwegian Industrial and Defense Research Development, and the theme of the second session was Status and Trends in International Aerospace Cooperation. The presentation of each speaker is included. Author

**N74-23495#** Advisory Group for Aerospace Research and Development, Paris (France)

**INTERNATIONAL CONFERENCE MANAGEMENT**

George Zinnemann. Jan 1972. 18 p. Revised

Avail NTIS HC \$4.00

Some guidelines are presented for individuals involved in managing and participating in international conferences. The material is divided into four sections, each of particular significance to the project officer, the host organization, the meeting chairman and the speakers, respectively. D L G

**N74-23496#** Advisory Group for Aerospace Research and Development, Paris (France)

**DIRECTOR'S ANNUAL REPORT TO THE NORTH ATLANTIC MILITARY COMMITTEE, 1971**

Mar 1972. 82 p.

Avail NTIS HC \$7.25

The report has been prepared in the context of the total AGARD 1971 Technical Program which is carried out by the AGARD Panels, the Consultant and Exchange Program, and the Military Committee Studies Program. The achievements are reported in terms of: (1) the meeting which were held to bring together the leading personalities of the NATO nations in a particular field of science and technology for the common benefit of the NATO community; (2) the AGARD Series publication which were distributed and/or initiated as a result of these meetings for the purpose of assisting member nations in the effective use of their research and development capabilities; (3) the personnel that planned for and participated in the total program; and (4) the budget that supported this stimulus to the advances in the aerospace sciences relevant to strengthening the common defense posture. The Appendix contains the detailed program of the individual activities. Author

**N74-23497#** Advisory Group for Aerospace Research and Development, Paris (France)

**AGARD HANDBOOK (INCLUDING AGARD BY LAWS)**

Sep 1972. 31 p. Revised

Avail NTIS HC \$4.75

A handbook which presents an overview of the AGARD organizational structure is presented. Topics include historical background, military studies program panels and publications. The bylaws of AGARD are presented for reference purposes. S K W

**N74-23498#** Advisory Group for Aerospace Research and Development, Paris (France)

**HIGHLIGHTS AGARD'S TWENTIETH ANNIVERSARY, 1952-1972**

1972. 29 p.

Avail NTIS HC \$4.50

The first issue of AGARD's Highlights is presented. Changes and developments which have taken place since the establishment of AGARD in 1952 are detailed. Biographies are presented of the recipients of the first Von Karman Medals. S K W

**N74-23499#** Advisory Group for Aerospace Research and Development, Paris (France)

**DIRECTOR'S ANNUAL REPORT TO THE NORTH ATLANTIC MILITARY COMMITTEE, 1972**

1972. 80 p.

Avail NTIS HC \$6.00

Abstracts for AGARD series publications for 1972 are presented. Proceedings of panel meetings in the following subject areas are detailed: avionics, electromagnetic wave propagation, flight mechanics, fluid dynamics, guidance and control, propulsion and energetics, and structure and materials. A list of AGARD consultants and their subject specialties is also presented. S K W

**N74-23500#** Advisory Group for Aerospace Research and Development, Paris (France)

**HIGHLIGHTS, SPRING 1973**

1973. 32 p.

Avail NTIS HC \$4.75

Short articles on the progress and activities of AGARD panels are presented. Panels are included in the areas of avionics, electromagnetic wave propagation, flight mechanics, and structures and materials. A summary of the work completed on the new AGARD multilingual aeronautical dictionary is included along with a description of the plans for the publication of the collected works of Theodore Von Karman. K M M

**N74-23501#** Advisory Group for Aerospace Research and Development, Paris (France)

**INSTRUCTIONS TO AUTHORS OF AGARD MANUSCRIPTS TO BE SET BY THE PRINTERS. INSTRUCTIONS TO AUTHORS OF AGARD MANUSCRIPTS TO BE PREPARED CAMERA READY (INSTRUCTIONS A L'INTENTION DES AUTEURS DE MANUSCRITS AGARD DESTINEES A ETRE COMPOSE PAR L'IMPRIMEUR. INSTRUCTIONS AUX AUTEURS DE MANUSCRITS DE PUBLICATIONS AGARD DESTINEES A ETRE REPRODUITS PAR PHOTOGRAPHIE DIRECTE)**

Oct 1973. 8 p. Revised. In ENGLISH and FRENCH

Avail NTIS HC \$4.00

Instructions are given for those who are unable to use AGARD special layout paper for the preparation of manuscripts for AGARD publication. Also presented are the instructions for those who are preparing manuscripts for publication using the direct reproduction system. K M M

**X74-73503** Advisory Group for Aerospace Research and Development, Paris (France)

**SMALL TACTICAL MISSILES FOR 1980 AND BEYOND**

VOLUME 1 SUMMARY (LES PETITS MISSILES

FACTIQUES A L'HORIZON 1980 ET AU DELA TOME 1

SOMMAIRE)

Roger Maquet and Charles Boespeel. Dec 1973. 60 p. In FRENCH

AGARD AR 57-1 Vol 1-

NATO Confidential Report

The case is made in this report for a NATO approach to tactical missile developments for the 1980's via technology programmes which lead into building block programmes and capabilities systems having implications to more than one military domain and then for linking together these various separate development programmes into a planned development programme of the future of closely integrated missiles.

Based on a comprehensive survey of the advanced missile system technologies and supporting techniques which will be available by 1980-1985 and on the estimated characteristics of the target of the 1980's, this method of approach led to the definition of some 80 conceptual system designs corresponding to 41

missile system types classified into 7 target oriented missile families. These conceptual system designs are analyzed in order to derive the cases for commonality and modularity and the most promising technologies and techniques for the 1980's.

**X74-73504** Advisory Group for Aerospace Research and Development Paris (France)

**SMALL TACTICAL MISSILES FOR 1980 AND BEYOND**

**VOLUME 1: EXECUTIVE SUMMARY**

Roger Marquet and Charles Borgeaud Dec 1973 56 p

(AGARD-AR-57-Vol-1)

NATO Confidential Report

For abstract see X74-73503

**X74-73505** Advisory Group for Aerospace Research and Development Paris (France)

**SMALL TACTICAL MISSILES FOR 1980 AND BEYOND**

**VOLUME 2**

Roger Marquet and Charles Borgeaud Dec 1973 242 p

(AGARD-AR-57-Vol-2)

NATO Secret Report

For abstract see X74-73503

# AGARD INDEX OF PUBLICATIONS (1971 - 1973)

## PART II: INDEXES

SUBJECT INDEX

PERSONAL AUTHOR INDEX

CORPORATE SOURCE INDEX

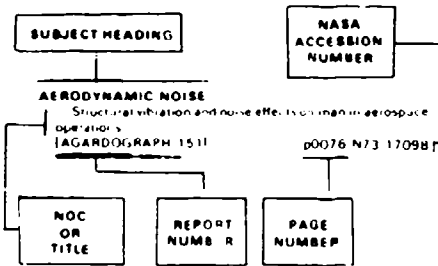
REPORT/ACCESSION NUMBER INDEX

ACCESSION/REPORT NUMBER INDEX

# SUBJECT INDEX

## AGARD INDEX OF PUBLICATIONS (1971-1973)

### TYPICAL SUBJECT INDEX LISTING



The subject heading is the key to the subject content of the document. A brief description of the document (e.g., title plus a title extension, or Notation of Content (NOC), is included for each subject entry to indicate the subject heading context. These descriptions are arranged under each subject heading in ascending accession number order. The report number helps to indicate the type of document cited. The page number identifies the page in the abstract section (Part I) on which the citation appears. The NASA accession number denotes the number by which the citation is identified on that page.

### A

#### A 4 AIRCRAFT

External store interference caused by rocket launch pad positioning on aircraft wing. p006 N71 19387

#### A 7 AIRCRAFT

A 7 aircraft airborne ground and shipboard data navigation alignment methodology. p0231 N73 20710

#### A 300 AIRCRAFT

Optimization and design of the rear fuselage of the A 300 B aircraft structure. p0298 N74 19614

#### ABLATION

Analysis of ablation processes for aerospace systems. [AGARD AG 161] p0299 N72 24959

#### ADORNALITIES

Standardization of tests and classification of the perceptual abnormalities in military personnel. p0072 N72 19123

Partial cerebral hypoxia in humans: a study of hypoxia models. p0180 N74 16186

#### Absorption Spectra

Spatial correlation of aircraft afterburner firing meter. p0129 N72 21146

#### ABSTRACTS

Current Abstracts: Aviation. p0169 N74 19739

#### AC GENERATORS

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Characteristics of a vectorial attenuator in an aircraft electrical power system. p006 N72 19387

Linear acceleration of impact type causing human injuries. p0098 N72 17119

Biodynamics of air blast during acceleration and deceleration events. p0100 N72 19114

Linear and angular acceleration in otology: human acceleration simulation in airplane airbag restraint systems and mathematical models of automobile crash loads. p0102 N72 19156

Physiological tests of vestibulo-ocular reflex by counterforce to determine effects of positive acceleration on dynamics of vestibular system of chinchilla monkeys. p0072 N72 25040

Relation between measured CG vertical accelerations and loads at T10 of human subjects. p0291 N73 16904

Control of aircraft yawing and roll during takeoff and landing. p0076 N73 17098

Counting acceleration meters mounted at center of gravity of various aircraft. p046 N73 20673

PIGA: Acceleration tests in vertical flight to test centrifuge and vibration tests of initial guidance systems. p0236 N74 14342

Acceleration protection system design: impact tests and restraint harnesses and ejection seats. p0104 N72 19157

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

Acceleration stresses (PHYSIOLOGY). p0068 N71 20358

Effects of positive G acceleration on blood oxygen saturation and plasma pressure in relation to high breathing and fluid fluctuations in whole body water in human respiration. p0068 N71 20358

#### ACCIDENT INVESTIGATION

Army helicopter accident analysis for defining impact injury problems and helping to crashworthiness. p0199 N72 19129

#### ACCIDENT PREVENTION

Safety tests and air bags for highway accident prevention. p0199 N72 19126

#### ACCLIMATIZATION

Northwestern University flight simulator: human adaptation and acclimatization to hypoxia. p0067 N72 20371

#### ACCURACY

Passive gravity gradient method for determination of Earth and Proton satellites. p0172 N71 2807

#### ACETYLENE

Carbon acetylene: properties of acetylene oxygen. p0153 N71 11664

#### ACOUSTIC FATIGUE

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part I. p0296 N72 29813

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part II. p0296 N72 29814

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part III. p0296 N72 29815

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part IV. p0296 N72 29816

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part V. p0296 N72 29817

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part VI. p0296 N72 29818

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part VII. p0296 N72 29819

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part VIII. p0296 N72 29820

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part IX. p0296 N72 29821

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part X. p0296 N72 29822

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XI. p0296 N72 29823

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XII. p0296 N72 29824

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XIII. p0296 N72 29825

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XIV. p0296 N72 29826

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XV. p0296 N72 29827

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XVI. p0296 N72 29828

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XVII. p0296 N72 29829

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XVIII. p0296 N72 29830

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XIX. p0296 N72 29831

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XX. p0296 N72 29832

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXI. p0296 N72 29833

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXII. p0296 N72 29834

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXIII. p0296 N72 29835

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXIV. p0296 N72 29836

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXV. p0296 N72 29837

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXVI. p0296 N72 29838

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXVII. p0296 N72 29839

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXVIII. p0296 N72 29840

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXIX. p0296 N72 29841

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXX. p0296 N72 29842

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXI. p0296 N72 29843

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXII. p0296 N72 29844

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXIII. p0296 N72 29845

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXIV. p0296 N72 29846

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXV. p0296 N72 29847

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXVI. p0296 N72 29848

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXVII. p0296 N72 29849

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXVIII. p0296 N72 29850

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XXXIX. p0296 N72 29851

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XL. p0296 N72 29852

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XLI. p0296 N72 29853

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XLII. p0296 N72 29854

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XLIII. p0296 N72 29855

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XLIV. p0296 N72 29856

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XLV. p0296 N72 29857

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XLVI. p0296 N72 29858

Analysis of acoustic fatigue effects on structures subjected to random and accelerated loading of aircraft. Part XLVII. p0296 N72 29859

- Analysis of helicopter internal and external noise levels for various flight conditions and timing of acoustic spectra p0052 N73 21055
- Analysis of acoustic factors involved in wind tunnel tests to show contributions from various sources p0173 N73 26247
- Development of method for calculating near field noise level of free jet and influence of ground effect on noise produced by V-STOL aircraft operation p0292 N73 29907
- Application of stress as test technique for determining response and life of aircraft structures subject to engine noise field excitation p0294 N73 29922

## ACOUSTIC SCATTERING

- Underwater acoustic beam width effects on signal scattering through surface of sea floor p0123 N72 16102

## ACOUSTIC SIMULATION

- Acoustic fatigue design data part 3 design criteria for aircraft structural elements to reduce effects of acoustic stress [AGARDGRAPH 162 PT 3] p0298 N74 19550

## ACOUSTICS

- Physiological and psychological limits and range of human response to acoustic stimuli p0067 N71 20352

## ACUITY

- Auditory evaluation of aging pilots hearing acuity in relation to flying time p0093 N71 22320

## ADAPTATION

- North Atlantic Treaty Organization conference on adaptation and accommodation in aerospace medicine [AGARD CP 82 71] p0067 N71 20351

- Stresses and adaptation problems associated with a gale wave to a range radar reaction time as a function of age p0069 N71 20360

- Effect of adaptation and dynamic dynamics on adaptability of human beings to degraded sensorial environments p0069 N71 20364

- Adaptability and receptivity factors affecting motion sickness susceptibility p0078 N73 21095

## ADAPTIVE CONTROL

- Adaptive and nonadaptive approach to pattern recognition with Bayesian and non-Bayesian techniques considered p0153 N73 11190

## ADAPTIVE FILTERS

- Matrix method for calculating adaptive filter while using fast Fourier transform digital processing p0132 N73 10197

- Fast Fourier transform digital processing as spectrum analyzer and adaptive filter p0132 N73 10198

- Automatic equalizers of telephone channels for fast transmission of digital data p0132 N73 10199

- Algorithms for adaptive digital filters of data communication channels p0132 N73 10200

## ADHESIVE BONDING

- Nondestructive tests and their application for inspection of adhesive bonded structures welded joints and riveted or bolted joints p0197 N72 19542

## ADIABATIC CONDITIONS

- Adiabatic compression method for determining self ignition delay in hydrocarbon fuel mixtures p0252 N72 11582

- Influence of adiabatic compression on power of hydrocarbon fuels and pumps p0066 N73 19255

## ADRENAL METABOLISM

- Temperature and noise radiation effects on human adrenal metabolism during vigilance task p0106 N72 19155

## ADRENERGICS

- Mental and cardiovascular acceleration stress effects on heart rate studied by beta altheine blockade p0165 N73 19149

## AERIAL PHOTOGRAPHY

- Matrix reconstruction technique in dynamic derivation of velocities in aerial photographs of highways p0152 N72 11142

- Aerial multispectral color photography for remote sensing of soils and rocks p0124 N72 10110

- Noise and error effects on differentially phase-coded modulation transmission of scanned aerial imagery p0131 N73 10190

- On-line computer technique for evaluating recommendations for image compression algorithms p0131 N73 10191

## AERODYNAMIC CHARACTERISTICS

- Conference on theoretical methods and wind tunnel facilities for transonic aerodynamic testing of aircraft at high Reynolds numbers p0011 N72 11951

- Transonic wind tunnel testing for predicting flight performance characteristics of aircraft p0013 N72 11861

- High Reynolds number aerodynamic ground testing by moving test specimens on rocket rails p0316 N72 11865

- Flight test procedures for determining stall and spin characteristics of high performance aircraft p0035 N72 20979

- Development of flight test procedures for use with advanced aircraft to determine cruise performance characteristics p0035 N72 20980

- Techniques and procedures for conducting flight tests of lifting body type aircraft during transonic and supersonic flight conditions p0035 N72 20986

- Development of performance data and stability and control characteristics from aircraft performance data in steady flight conditions p0036 N72 20992

- Aerodynamic characteristics of C-141B lifting V-STOL aircraft and comparison with handling qualities criteria documents p0038 N72 32023

- Analysis of aerodynamic characteristics of VJ-101C and OQ-31E V-STOL aircraft and comparison with criteria contained in handling requirements documents p0039 N72 32024

- Application of simulation and analysis techniques for establishing flying qualities criteria for piloted aircraft p0039 N72 32026

- Development and application of plotting to determine performance and handling criteria of aircraft p0039 N72 32028

- Properties of atmospheric turbulence at low altitudes and effect on aircraft during landing approach and takeoff p0039 N72 32030

- Application of model helicopter rotor experiments to determining dynamic stall of rotary wings and predicting aerodynamic loads developed p0017 N73 14002

- Numerical analysis of unsteady aerodynamic forces on helicopter rotor blades to determine lift distribution as function of velocity component normal to blades p0027 N73 14003

- Proceedings of conference on fluid dynamics of aircraft stall to include stall at direct stall aerodynamic characteristics of various military aircraft [AGARD CP 102] p0041 N73 14998

- Design characteristics and performance of airfoils with high lift at low and medium subsonic speeds and various angles of attack p0042 N73 15004

- Analysis of aerodynamic processes occurring in flow past unpowered multi-element airfoils in high lift attitude p0042 N73 15007

- Analysis of aerodynamic stall characteristics of wing sections with high lift devices in two dimensional flow p0042 N73 15008

- Development of procedure for determining characteristics of high lift systems where viscous effects dominate p0042 N73 15009

- Analysis of static and post stall characteristics of F-111 aircraft and development of pressure techniques to obtain aerodynamic derivatives p0043 N73 15013

- Post stall aerodynamic characteristics of Harrier GR-1 aircraft and development of lift augmenting devices p0043 N73 15014

- Development of F-28 transport aircraft wing and analysis characteristics to show effects of boundary layer fences p0043 N73 15015

- Wind tunnel tests to obtain predicted estimates of stall speed and low speed performance of Boeing 747 aircraft p0043 N73 15016

- Aerodynamic design engineering development and flight testing of naval aircraft for operation at high angles of attack p0043 N73 15020

- Conference on flight handling qualities and requirements p0044 N73 16993

- Revisions to V-STOL handling qualities based on criteria p0044 N73 16994

- Role of theory and calculations in refinement of flying qualities p0044 N73 16999

- Predicting flying qualities by wind tunnel tests p0045 N73 17000

- Effect of angle of attack on aerodynamic characteristics of supersonic aircraft p0045 N73 17003

- Evaluation of fluid dynamics of aircraft stalling to determine effects of three dimensional flow wing sweep back and tip effects p0046 N73 18023

- Consensus of speed report establishment by SA-341 helicopter for future aircraft preparation procedures and requirements for complete completion p0047 N73 21018

- Review of lifting rotor technology and comparison of lifting rotor performance with standard rotary wings p0048 N73 21027

- Proceedings of conference on fluid dynamics of rotary wings and aerodynamic characteristics of rotary wing systems [AGARD CP 111] p0049 N73 21031

- Analytical and experimental techniques to define geometry of vertical field of hovering rotary wing and effect on rotor performance p0049 N73 21032

- Investigations in basic rotary wing design and tests to determine effects on helicopter performance p0050 N73 21038

- Aerodynamic characteristics of rotary wings under axial flow conditions and development of numerical analysis techniques p0050 N73 21039

- Development of method for predicting performance of heavily loaded propellers and rotors in steady hovering flight p0050 N73 21040

- Analysis of unsteady aerodynamic environment of rotary wings and research projects to improve understanding of rotor unsteady loads p0050 N73 21041

- Analysis of unsteady aerodynamic loading on external section of helicopter rotor blade in stall or hovering flight under compressible flow conditions p0050 N73 21044

- Development of concept of circulation control applied to rotary wings to show effects on hover, transition, and high speed cruise performance p0051 N73 21050

- Wind tunnel tests to determine effects of rotor loading on helicopter performance and application for helicopter design optimization p0051 N73 21052

- Proceedings of conference on rotary wings to investigate rotor wakes aerodynamic characteristics at hover and high advance ratio and aerodynamic noise properties [AGARD AR 61] p0052 N73 21937

- Analysis of aerodynamic and dynamic properties of rotary wing aircraft for application to design development and evaluation of helicopters p0017 N73 22948

- Basic dynamics of rotary wings mechanics of helicopter flight and aerodynamic characteristics of advanced rotary wing concepts and configurations p0017 N73 22951

- Analysis of effects of aerodynamic and dynamic parameters on design synthesis of rotary wings and application of optimization techniques p0018 N73 22958

- Flight test procedures for rotary wing aircraft with emphasis on performance and flying qualities p0018 N73 22959

- Numerical analysis of aircraft takeoff performance based on phases of takeoff and forces exerted on aircraft as basis for aircraft design p0053 N73 24051

- Analysis of aerodynamic characteristics affecting selection of short takeoff transport aircraft p0055 N73 27012

- Aerodynamic characteristics of high lift wing concepts for application to commercial short takeoff transport aircraft p0292 N73 29908

- Drag of supersonic airfoils in transonic flow comparison with conventional airfoil drag coefficients p0020 N74 14719

- Development of techniques to measure lift drag of a US Navy fighter airplane and correlation of flight measured drag with wind tunnel data p0022 N74 14734

- Rational selection of design gust loads in relation to present and proposed airworthiness requirements effects of atmospheric turbulence on aerodynamic configuration of short haul aircraft p0059 N74 11140

## AERODYNAMIC COEFFICIENTS

- Numerical analysis of aerodynamic loads and coefficients for tandem and T-tail surfaces harmonically oscillating in subsonic flow p0007 N71 29335

- AGARD report on engine airplane interference and wall correction in transonic wind tunnel tests [AGARD AR 36 71] p0010 N71 36400

- Conclusions and recommendations concerning wind tunnel tests of interaction between engine flow and wall corrections in transonic wind tunnels p0010 N71 36401

- Wall corrections for airplanes with interference lift in transonic wind tunnel tests p0011 N71 36403

- Wind tunnel measurements of Reynolds number effect on force and pressure coefficients for slender delta wing at transonic speed p0012 N72 11863

- Comparison of flight test and wind tunnel data to determine areas of agreement when nonlinearities appear in aerodynamic coefficients of slender wing aircraft p0036 N72 20990

- Development of numerical process for extracting aerodynamic coefficients from flight test data p0038 N72 20991

- Application of blockage correction factor to wind tunnel test measurements on aircraft models p0042 N73 15006

- Analysis of aerodynamic processes occurring in flow past unpowered multi-element airfoils in high lift attitude p0042 N73 15007

- Design aspects of stall of powered lift aircraft with externally down flaps and methods for predicting increment in maximum lift coefficient due to power p0042 N73 15011

- Influence of degree of turbulence on aerodynamic coefficients of cascades p0268 N73 19198

- Effect of axial velocity ratio on aerodynamic coefficients of compression cascade in viscous flow p0269 N73 19804

- Presentation of helicopter level flight performance as power coefficient compared with tip speed of advance ratio for range of thrust coefficients p0047 N73 21014

- Analysis of effects of Reynolds number on aerodynamic stalling of rotary wings and relationship of Reynolds number to aerodynamic coefficients of blade elements p0018 N73 22957

- Aerodynamic coefficients for calculating transport aircraft performance using wind tunnel and scale models p0053 N73 24016

- Objectives of dynamic testing in low speed wind tunnels and techniques for measuring oscillatory derivatives and transient motion effects p0173 N73 26244

- Appendix A data item service for aircraft drag estimation collection dissemination and development of aerodynamic drag prediction data p0020 N74 14717

- Transonic drag due to lift of planar jet flapped airfoils p0020 N74 14720

- An assessment of the accuracy of transonic drag measurements in a large modern wind tunnel aerodynamic coefficients of bodies of revolution for mathematical modeling p0022 N74 14736

## AERODYNAMIC CONFIGURATIONS

- Swept wing body configurations for reduced drag at supersonic speed p0002 N71 19158

- Computer program for determining low speed interference effects of flow fields about arbitrary bodies by superposition p0005 N71 19377

- Symposium on unsteady aerodynamics forces loads and configurations for aeroblastic analysis of interfering surfaces [AGARD CP 80 71 PT 2] p0008 N71 29338

- Analysis of aerodynamic characteristics of VJ-101C and OQ-31E V-STOL aircraft and comparison with criteria contained in handling requirements documents p0039 N72 32024

- Development of criteria specification for supersonic transport aircraft and application to safe handling qualities for all regimes of flight operations p0039 N72 32027
- Analysis of factors in stall and post stall operating conditions and effect on aircraft configurations p0039 N72 32025
- Proceedings of conference to analyze static and dynamic loads exerted on helicopter rotary wings and application to improved helicopter design [AGARD R 595] p0016 N73 14000
- Design characteristics and performance of rotors with high lift at low and medium subsonic speeds and various angles of attack p0042 N73 15004
- Aerodynamic configurations of swept wings to improve lift performance at stall in higher range of subsonic speeds p0042 N73 15010
- Modifications of Jet Provost and Siskinmaster trainer aircraft to provide adequate stall warning without excessive penalty on maximum lift at low speed p0042 N73 15012
- Analysis of high subsonic and transonic characteristics of fighter aircraft and factors affecting aerodynamic boundaries for various wing design parameters p0043 N73 15019
- Flight tests of Westland Scout helicopter fitted with reduced scale version of rotor rotor to determine aeroelasticity and handling characteristics p0047 N73 21017
- Survey of problems encountered in prediction of structural design loads and aeroelastic stability margins during development of rotary wing aircraft p0048 N73 21020
- Aerodynamic characteristics of stall controlled rotor and fundamental problems of stopped rotor aircraft p0048 N73 21024
- Development of jet flap rotor and application to heavy helicopter and stoppage rotor designs p0048 N73 21025
- Review of stopping rotor technology and comparison of lifting rotor performance with standard rotary wings p0048 N73 21027
- Development of advancing blade concept rotary wing and wind tunnel tests of full scale model p0048 N73 21029
- Proceedings of conference on fluid dynamics of rotary wings and aerodynamic characteristics of rotary wing systems [AGARD CP 111] p0049 N73 21031
- Aerodynamic characteristics of rotary wings under ideal flow conditions and development of numerical analysis techniques p0050 N73 21039
- Analysis of unsteady aerodynamic environment of rotary wings and research projects to improve understanding of rotor unsteady airloads p0050 N73 21041
- Effect of rotary wing airload modifications on performance, stability and control of helicopters p0051 N73 21045
- Development of technique for rotor blade design and measurement of pressure distribution along the blade chord and across blade wake in rotor tip in flight p0051 N73 21047
- Development of algorithm for calculating induced flow about arbitrary planform rotors and application to analyzing various rotary wing configurations p0051 N73 21048
- Development of concept of circulation control applied to rotary wings to show effects on hover, transition, and high speed cruise performance p0051 N73 21050
- Aerodynamic dynamic and aeroelastic problems in rotary wing design of helicopters and V-STOL aircraft with application to helicopter systems p0051 N73 21051
- Wind tunnel tests to determine effects of nonrotating component on helicopter performance and application for helicopter design optimization p0051 N73 21052
- Fundamentals of rotary wing aerodynamics and application to performance considerations of helicopters p0051 N73 21055
- Effects of aerodynamic performance of rotary wings and procedures for predicting aerodynamic forces on rotary wing blades p0051 N73 21056
- Effects of aerodynamic drag on rotary wing performance and methods for reducing influence of stall and compressibility parameters p0051 N73 21058
- Development and application of aircraft performance prediction methods for subsonic and supersonic transport aircraft p0051 N73 21062
- AGARD R 581 p0052 N73 24042
- Parametric and optimization techniques for aircraft design systems to show performance of state flow for various aircraft configurations p0053 N73 24049
- Review of V-STOL development programs to compare basic characteristics of XC-142A, X-19 and X-22A aircraft under various flight conditions p0054 N73 27003
- Design, development and flight characteristics of VAK 191 B V-STOL strike reconnaissance aircraft p0054 N73 27006
- Propulsive lift technology program for development of short takeoff aircraft propulsor systems and lift augmentation devices p0055 N73 27009
- Design, development and evaluation of Buffalo Sky Augmentor Wing research aircraft using internally blown flap for lift augmentation p0055 N73 27010
- Technical evaluation report on fluid dynamics of rotor systems. Meeting on Aerodynamic Drag p0018 N74 10905
- AGARD R 581 p0018 N74 10905
- Rotary wing design methodology based on computerized aerodynamic blade loads analysis p0056 N74 10909
- Helicopter rotor loads prediction and assessment and techniques for numerical analysis of aerodynamic loads p0056 N74 10911
- Rotor system design and evaluation using a general purpose helicopter flight simulation program p0056 N74 10913
- The prediction of loading actions on high speed semi-rigid helicopters p0056 N74 10914
- Loads prediction methods for helicopter rotors p0056 N74 10915
- Technical evaluation report on application of aerodynamic drag research to design of aircraft p0019 N74 14710
- Measurements of the drag of some characteristic aircraft configurations immersed in turbulent boundary layers p0019 N74 14714
- Remarks on methods for predicting viscous drag and aerodynamic drag prediction for high angles of attack and multielement airfoils p0020 N74 14718
- New investigations for reducing the base drag of wings with a blunt trailing edge effects of splitter plates and splitter wedges on aerodynamic drag coefficients p0020 N74 14723
- Drag of thin bodies for pilots at high altitude p0021 N74 14731
- Development of techniques to measure in flight drag of a US Navy fighter airplane and correlation of flight measured drag with wind tunnel data p0022 N74 14734
- AERODYNAMIC DRAG
- Three dimensional interaction in half cone pressure fields and drag research on various mounted adjacent to aircraft fuselage p0003 N71 19367
- Wind tunnel evaluation of lifting body store configurations for captive flight drag and separation characteristics p0006 N71 19386
- Transonic wind tunnel determination of Reynolds number effect on jet flap drag divergence, pressure distribution and buffet onset p0012 N72 11861
- Comparison of wind tunnel and theoretical techniques for determining full scale aerodynamic flight drag factors [NASA TM X 67413] p0013 N72 11869
- External drag characteristics of jet engine exhaust nozzles using wind tunnel tests p0026 N72 16707
- Jet effects on boat hull pressure drag at supersonic speeds in single and twin propulsive jets p0026 N72 16708
- Effects of aerodynamic drag on rotary wing performance and methods for reducing influence of stall and compressibility parameters p0017 N73 22954
- Technical evaluation report on fluid dynamics of rotor systems. Meeting on Aerodynamic Drag p0018 N74 10905
- Aerodynamic Drag p0018 N74 14709
- AGARD CP 124 p0018 N74 14709
- Technical evaluation report on application of aerodynamic drag research to design of aircraft p0019 N74 14710
- A survey of drag prediction techniques applicable to subsonic and transonic aircraft design p0019 N74 14711
- Aerodynamic drag of a thin of several body shapes at subsonic, transonic and supersonic Mach numbers p0019 N74 14712
- On some basic and new aspects about the drag problem of wings and bodies in supersonic flows p0019 N74 14713
- Measurements of the drag of some characteristic aircraft configurations immersed in turbulent boundary layers p0019 N74 14714
- Problems of estimating the drag of a helicopter: correlation of flight test data and wind tunnel test data p0019 N74 14715
- Aircraft drag prediction for project appraisal and performance estimation p0019 N74 14716
- Appendix A: data base for aircraft drag estimation: a review of data base and development of aerodynamic drag prediction data p0020 N74 14717
- Remarks on methods for predicting viscous drag and aerodynamic drag prediction for high angles of attack and multielement airfoils p0020 N74 14718
- Drag of supercritical airfoils in transonic flow comparison with conventional airfoil drag coefficients p0020 N74 14719
- Transonic drag prediction of planar jet flapped airfoils p0020 N74 14720
- Comparison of various methods for calculating profile drag from pressure measurements in the near wake at subsonic speeds p0020 N74 14721
- Drag and separation effects of separated flow on aerodynamic drag p0020 N74 14722
- New investigations for reducing the base drag of wings with a blunt trailing edge effects of splitter plates and splitter wedges on aerodynamic drag coefficients p0020 N74 14723
- A study of flow separation in the base region and its effects on drag prediction in flight correlation between propulsive jet and free stream flow p0020 N74 14724
- Assessment of the flow field of a stall actively controlled airfoil p0021 N74 14726
- The problem of estimating a modern high thrust engine on a twin jet transport aircraft p0021 N74 14727
- The drag resulting from three dimensional separation caused by boundary layer vortices at transonic subsonic and supersonic flow p0021 N74 14728
- The drag of external blunt bodies in supersonic flow and alternative drag reduction by reflexing development of new aircraft configurations p0021 N74 14729
- Drag components in wind tunnel effects of compressibility and friction drag p0021 N74 14730
- Drag of thin bodies for pilots at high altitude p0021 N74 14731
- A review of supersonic sphere drag from the continuum to the free molecular flow regime p0022 N74 14732
- Development of techniques to measure in flight drag of a US Navy fighter airplane and correlation of flight measured drag with wind tunnel data p0022 N74 14734
- Review of drag measurements from flight tests of various aircraft with comparisons to wind tunnel predictions p0022 N74 14735
- An assessment of the accuracy of transonic drag measurement in a large modern wind tunnel aeroblastic coefficients of bodies of revolution for mathematical modeling p0022 N74 14736
- AERODYNAMIC FORCES
- Symposium on unsteady aerodynamic forces loads and configurations for aeroblastic analysis of interfering surfaces [AGARD CP 80 71 PT 2] p0006 N71 29338
- Computer programs for calculating airforce coefficients of wing horizontal tail and fin horizontal tail oscillating in subsonic flow p0009 N71 29342
- Method for calculating flutter using interference aerodynamic forces between wing and tail p0011 N71 29345
- Calculated values of air forces on oscillating thin wings obtained by linearized potential flow p0010 N71 35198
- Design and development of instrument for measuring aerodynamic loads and fatigue characteristics of aircraft structures [AGARD R 597] p0041 N73 13019
- Analysis of velocity profiles in boundary layer produced by incompressible flow during takeoff p0041 N73 15001
- Collection and processing of gust load data obtained from counting accelerometers mounted at center of gravity of various aircraft p0046 N73 20023
- Calculation and measurement of aerodynamic forces on oscillating airfoil with and without aerodynamic staling p0050 N73 21042
- Influence of various aerodynamic forces on rectangular wing performance with harmonic movement parallel to free flow movement p0050 N73 21043
- A review of supersonic sphere drag from the continuum to the free molecular flow regime p0022 N74 14732
- Interfering lifting surfaces in unsteady subsonic flow. Comparison between theory and experiment [AGARD R 614] p0023 N74 18654
- AERODYNAMIC HEATING
- Effects of streamline curvature on aerodynamic flow applied to boundary layer conditions on wing sections of turbomachine blades [AGARD A 169] p0184 N74 12042
- AERODYNAMIC INTERFERENCE
- Integrated rotor body loads prediction p0057 N74 10916
- Comments on NASA Langley research on transonic unsteady aerodynamics flutter calculation methods [NASA TM X 69997] p0023 N74 18652
- Aerodynamic interference induced by reaction jets: flow distribution of some of supersonic piston jet interacting with transverse external flow p0184 N74 18923
- AERODYNAMIC LOADS
- Computerized prediction of interference flow fields for wing fuselage store locations on bomber aircraft p0005 N71 19381
- Numerical analysis of aerodynamic loads on wing and tail surfaces with oscillation in unsteady supersonic and subsonic flow including interference lift [AGARD CP 80 71 PT 2] p0007 N71 29331
- Aerodynamic load prediction for rotating surfaces in unsteady supersonic and subsonic flow p0007 N71 29334
- Numerical analysis of aerodynamic loads on a two element tandem and T-tail surface harmonically oscillating in subsonic flow p0007 N71 29335
- Wing interference lift line lattice simulation and application to aerodynamic loads on tandem wings in unsteady flow p0008 N71 29336
- Boundary layer method for calculating aerodynamic loads on tandem delta wings with oscillations in supersonic flow p0008 N71 29337
- Symposium on unsteady aerodynamic forces loads and configurations for aeroblastic analysis of interfering surfaces [AGARD CP 80 71 PT 2] p0006 N71 29338
- Reaction of subsonic unsteady aerodynamic loads on lifting surfaces p0009 N71 29342
- Survey of aerodynamic industry for alternative various techniques used in determining internal loads of lifting surfaces stability control and load alleviation devices structural loads [AGARD R 592] p0041 N73 13019
- Design and development of instrument for measuring aerodynamic loads and fatigue characteristics of aircraft structures [AGARD R 597] p0041 N73 13019
- Proceedings of conference to analyze static and dynamic loads exerted on helicopter rotary wings and application to improved helicopter design [AGARD R 595] p0016 N73 14000
- Application of computerized planform expansion to determining dynamic effects of rotary wings and prediction of aerodynamic loads developed p0017 N73 21052







## AIR TO AIR MISSILES

- A preliminary study on the influence of fuel staging on nitric oxide emissions from gas turbine combustors p0221 N74 14301
- Motorist point of view on the effects of low burning rates on pollution p0221 N74 14303
- Technical evaluation of an AGARD Technical Meeting on Atmospheric Pollution by Aircraft Engines - requirement to analyze contribution to air pollution near airports from various sources [AGARD AR 63] p0222 N74 15349
- AIR TO AIR MISSILES**
- Missile requirements for air to air missile and digital computer program to synthesize requirements into preliminary design p0226 N72 27682

## AIR TO SURFACE MISSILES

- Initial guidance techniques for midcourse guidance and terminal guidance systems with application to control and guidance of tactical standoff missiles p0227 N72 27691
- Life cycle cost analysis of initial navigation systems for aircraft and air to surface missiles p0232 N73 20117

## AIR TRAFFIC CONTROL

- Proceedings of conference on air traffic control developments and procedures [AGARD CP 105] p0232 N73 23689
- Air traffic control facilities operated by U.S. military forces and developments in improved air traffic control systems p0232 N73 23690
- Characteristics of air traffic control system to include detection of electronic components and projects for developing improved equipment p0232 N73 23692
- Development of automated air traffic control system using computer techniques to provide flight safety for increased air traffic p0232 N73 23693
- Organization functions and capabilities of automated air traffic control system for Rome, Italy p0232 N73 23694
- Integrated SALVAN VOP and DME system for locating and controlling high altitude aircraft p0232 N73 23695
- Status and trends of civil air traffic control systems and development of automated network for increased flight safety p0233 N73 23696
- Comparison of cost complexity and cockpit workload for seven area navigation system configurations p0233 N73 23697
- Analysis of North Atlantic air route structure to determine impact of initial navigation and satellite surveillance on separation reduction p0233 N73 23699
- Analysis of terminal air traffic control procedures to determine impact of automation on air traffic controller personnel p0233 N73 23700
- Numerical analysis of automatic control and sequencing of air traffic control operations in near terminal area p0233 N73 23701
- Analysis of short takeoff and landing aircraft landing guidance systems and application of air traffic control procedures for improved sequencing p0233 N73 23703
- Development and characteristics of air traffic management system for operation of military aircraft under instrument meteorological conditions p0234 N73 23704
- Development and characteristics of microwave landing system with emphasis on functional design requirements for airborne equipment p0234 N73 23705
- Development of Doppler microwave landing system and techniques for eliminating effects of multipath transmissions p0234 N73 23706
- Development and characteristics of forward area heading and landing guidance for military aircraft operations p0234 N73 23708
- Application of artificial satellites for data acquisition and communication functions in air traffic control system p0234 N73 23709
- Development of high bandwidth time division communications system to provide ground based wide area position location system p0234 N73 23711
- Development and characteristics of system for separation and control of aircraft to avoid midair collisions p0235 N73 23712
- Performance tests of an air traffic control system to determine effectiveness in prevention of midair collisions p0235 N73 23713
- Analysis of air traffic controller responses under stress conditions to show effects of accuracy, quality and comprehensiveness of available data p0235 N73 23714
- Analysis of man-machine interfaces and system reliability for air traffic control automation systems p0235 N73 23715
- Analysis of interface between controller and computer in automated air traffic control system p0235 N73 23716
- Analysis of development program for employing IIS air traffic control procedures for 1980 time period p0235 N73 23718
- Conceptual analysis of proposed common area navigation and identification system for military applications p0235 N73 23719
- Analysis of common communications and standardization equipment for initial and proposed system for improvement in capability p0236 N73 23720
- Analysis of integrated communications, navigation and identification system for aircraft operations and proposals for improvement in capability p0236 N73 23721
- An author's experience with a new level of air traffic control system for the future p0238 N74 17777

## AIR TRANSPORTATION

- Stresses and adaptation problems associated with large scale long range rapid reaction time aerial troop deployments p0269 N71 20360
- United States Department of Transportation research program for high altitude pollution p0217 N74 14273

## AIR WATER INTERACTIONS

- Influence of solar energy absorption and air water interactions on seasonal thermocline of sea p0241 N73 33623

## AIRBORNE EQUIPMENT

- Cost ownership analysis of airborne equipment p0190 N71 36784
- Conference on propagation ranges of microwave infrared and photographic remote sensing systems for pollution detection and sea state roughness measurements [AGARD CP 90 71] p0121 N72 16085
- Airborne remote multispectral photographic infrared and side looking radar sensing for locating construction materials p0121 N72 16087
- Analysis of remote Arctic ice pack sensing data obtained by submarine sonar, airborne laser and infrared scanning imagery p0121 N72 16088
- Design and performance of microwave radiometer for air-sea sensing of sea ice thickness p0121 N72 16089
- Impact of technological development on airborne data acquisition system and ground data processing station p0195 N73 19457
- Analysis of effect of mass on operation of airborne superconductor magnetic system with aluminum stabilized conductor p0363 N73 19034
- Characteristics of large lightweight saddle coil superconducting dipole magnet for airborne magnetic hydrodynamic generators p0364 N73 19038
- Characteristics of airborne area navigation equipment and application to air traffic control functions p0233 N73 23698
- Development and characteristics of microwave landing system with emphasis on functional design requirements for airborne equipment p0234 N73 23705
- Aircraft navigation systems testing with a high precision reference development of Completely Integrated Reference Instrumentation System (CIRIS) p0237 N74 14353

## AIRBORNE SPACEBORNE COMPUTERS

- Computerized Apollo spacecraft attitude control system p0278 N72 12870
- Software and hardware technology for application of computer systems in guidance and control of ballistic vehicles [AGARD CP 158] p0155 N72 21211
- Application of digital computer techniques to aerospace systems and impact of new technologies p0155 N72 21212
- Advantages and disadvantages of tested and integrated computer system organizations for utilization in aerospace systems p0155 N72 21213
- Hardware organization and system design of guidance and control computers p0155 N72 21214
- Generation and checkout of computer programs for real time control of aerospace vehicles p0155 N72 21215
- Programming characteristics of future guidance and control computers p0156 N72 21216
- Data word length considerations for aerospace computer implementation to obtain required precision level p0156 N72 21217
- Aerospace computer memory technology and application of particular techniques to various system requirements p0156 N72 21218
- Aerospace computer input output techniques for control operation in design phase of interface equipment p0156 N72 21219
- Fault isolation capabilities for general purpose digital computer used in guidance and control applications p0156 N72 21220
- Guidance and control computer activated display system techniques p0156 N72 21221
- Analysis of tasks required for data processing equipment in advanced aircraft navigation systems p0156 N72 21222
- Central digital computers for helicopter guidance and control systems p0156 N72 21223
- Navigation guidance computer requirements for integrated navigation system using combination of Doppler, inertial, Doppler and terrain mapping p0157 N72 21224
- Application of airborne digital computers to track C/D and Omega navigation and guidance systems p0157 N72 21225
- Selection of computers for satellite based navigation and guidance system designed for aircraft users p0157 N72 21226
- Digital computers for navigation and guidance systems and fire control systems in tactical aircraft p0157 N72 21227
- Mainframe aircraft navigation display and computer system p0157 N72 21228
- Mathematical models of strong and weakly interacting coordinates and time at data superimposed for map p0234 N73 22533
- Onboard computer for a manned control of manned aerospace system considering human factors integration [AGARD CP 114] p0238 N73 23881
- Computerized integrated navigation and control system with graphical display for a manned space flight p0238 N73 23882

- Design of airborne flight data transmission system for automatic acquisition and tracking p0278 N73 23885
- Space station information subsystem for automatic support of manned operations p0279 N73 23887
- Feasibility of automated spacecraft monitoring using real time computer telemetry p0279 N73 23888
- Simulation model for optimum spaceborne computer system design controlling shuttle booster subsystems p0279 N73 23891
- Onboard computer system for in-flight monitoring of space shuttle in support of flight crew p0280 N73 23893
- Systems design for spaceborne computer engineering module p0280 N73 23894
- Computerized inertial guidance system for aircraft flight control p0280 N73 23895
- Computerized automated avionics system with electronic display for Comet 4 aircraft navigation p0280 N73 23896
- Serial digital data bus for integrated avionics system interface p0281 N73 23902

## AIRCRAFT

- Cost effectiveness of built-in test provisions in aircraft operations p0189 N71 36780
- AIRCRAFT ACCIDENT INVESTIGATION**
- Accident investigations, flight control systems and operational recordings for improved aircraft flight safety [AGARD CP 75 71] p0027 N71 23410
- Causing accidents investigations for Hawker Siddeley 748 aircraft with performance measurements on runway surfaces p0028 N71 23417
- Pattern of accident distribution for V-5101 aircraft in United States of America p0028 N71 23426
- Flight mechanics problems in accident investigations for V-101 aircraft p0030 N71 23428
- Weather factors in a low level transport aircraft accident p0032 N71 23431
- Reliability design of manned supersonic aircraft considering safety hazards p0278 N73 23883
- The psychologic stress in aircraft accident investigation p0107 N74 18803

## AIRCRAFT ACCIDENTS

- Influence of eleven potential factors in aircraft carrier landings and accidents p0070 N71 20369
- Aircraft accident injuries and reconstruction from linear impact p0069 N72 19123
- Personal observations of 340 fatal aircraft accidents for confirmation of observations by victims p0095 N72 19124
- History of aircraft crash injury studies and facilities for simulation p0103 N72 19150
- Protective helmets designed to lessen effects of head injury due to impact in aircraft accidents p0104 N72 19160
- Analysis of spatial disorientation occurrences among military pilots and factors according to types of aircraft and nature of accidents p0071 N72 25033
- Analysis of military aircraft accidents caused by spatial disorientation p0071 N72 25034
- Statistical analysis of military aircraft accidents to determine accidents caused by spatial disorientation p0071 N72 25035
- Psychophysiological and environmental factors involved in aircraft accidents of military aircraft and effect of flying experience in reducing spatial disorientation p0071 N72 25036
- German Air Force experiences with certain criteria for granting a waiver p0087 N74 18806
- Behavioral aspects of aircraft accident conference on human factors research projects for reduction of pilot error aircraft accidents [AGARD CP 132] p0106 N74 18797
- Pilot factors in aircraft accidents of the German Federal Air Force p0106 N74 18799
- Human factors approach to aircraft accident analysis: development of flying error and accident analysis to reduce human error in aircraft accidents p0107 N74 18799
- The human factors involved in aircraft accident patterns: statistical analysis of CF-104 aircraft accident patterns p0107 N74 18800
- The human cost and factor analysis of pilot error in a US Army aviation p0107 N74 18803

## AIRCRAFT APPROACH SPACING

- Numerical analysis of optimal control and sequencing of air traffic control operations in near terminal area p0233 N73 23701
- Analysis of short takeoff and landing aircraft landing guidance systems and applications of air traffic control procedures for improved sequencing p0233 N73 23702

## AIRCRAFT CARRIERS

- Influence of eleven potential factors in aircraft carrier landings and accidents p0070 N71 20369
- Flight test to determine suitability of a carrier for operation with a small aircraft p0033 N72 20998
- Analysis of carrier operation data for display in simulation, pattern analysis and trend contribution to display resolution temporal heading and altitude reports p0275 N72 27664
- Flight variable strategy and time investigations during approach to carrier deck p0275 N72 27664
- Parameters of approach to carrier deck p0275 N72 27664
- AIRCRAFT COMMUNICATION**
- TAM-TAM system for communication between aircraft and ground stations p0235 N73 23719



## AIRCRAFT EQUIPMENT

- Assessment of high temperature stability of synthetic lubricants for aircraft gas turbines. p0254 N72 11695
- Analytical methods for early stage detection of oil deterioration in aircraft engines. p0254 N72 11698
- Thermal stability of dimethyl propargyl ester based lubricants for aircraft engines. p0254 N72 11699
- Feasibility analysis of solid lubricated ball bearings for aircraft propulsion systems application. p0255 N72 11700
- Engine aircraft interference thrust inlet nozzles and propulsion systems conference. p0263 N72 16685
- [AGARD CP 91-71] p0263 N72 16685
- Program design for study of engine aircraft interference problems. p0263 N72 16686
- International survey of air pollution by aircraft engines and fuel. p0277 N72 21590
- [AGARD AR 40] p0277 N72 21590
- Engine airplane interference corrections in calculating model aircraft performance from wind tunnel test data. p0277 N72 21591
- Analysis of gas turbine engine requirements and performance when main propulsion system furnishes auxiliary power source. p0265 N73 19350
- Performance of aircraft gas turbine components in hot corrosion environments. p0261 N73 23539
- Chemical and mechanical properties of aircraft gas turbine engine components. p0261 N73 23600
- Analysis of parameters affecting choice of engine for transport and combat aircraft during development. p0253 N73 24048
- Analysis of air pollution caused by aircraft engine emissions in vicinity of airports and en route with a pollution sight area. p0271 N73 24785
- Analysis of techniques and equipment required to conduct test of jet aircraft engine models in wind tunnels. p0173 N73 26245
- Proposed cell technology program for development of short takeoff aircraft propulsion systems and lift augmentation devices. p0255 N73 23009
- Detailed exhaust emission measurements of three different turbofan engine designs. p0217 N74 14276
- Photo oxidation of aircraft engine emissions at low and high altitudes. p0218 N74 14277
- Effect of supersonic transport upon the ozone layer studied in a two dimensional photochemical model with transport. p0218 N74 14278
- Technology for the reduction of aircraft turbine engine exhaust emissions. p0221 N74 14300
- Design and evaluation of combustors for reducing aircraft engine pollution. p0221 N74 14302
- Aircraft gas turbine performance in the presence of low minimum effect on engine performance. p0221 N74 14304
- Technical evaluation report on AGARD Technical Meeting on Atmospheric Pollution by Aircraft Engines, requirements to analyze contribution to air pollution near airports from various sources. p0222 N74 15349
- [AGARD AR 63] p0222 N74 15349
- ### AIRCRAFT EQUIPMENT
- Procedure for measuring performance of aircraft fire extinguishing powders. p0253 N72 11691
- Negative g strap for restraint and performance during aircraft maneuvers, vibration and crash impact. p0104 N72 19158
- Operating characteristics of integrated aircraft command and control system. p0225 N72 22637
- Procedure for determining noise levels in flight test measuring systems. p0195 N73 16456
- Simulation of flight in Concorde for long range characteristics of flight control system. p0086 N73 17013
- Evaluation of conference to investigate current and future development in aircraft electrical and auxiliary power systems. p0063 N73 18081
- [AGARD AR 50] p0063 N73 18081
- Proceedings of conference on application of superconductivity techniques to auxiliary power systems for aircraft and missiles. p0063 N73 19030
- [AGARD CP 104] p0063 N73 19030
- Characteristics of functional alternators and aircraft electrical power systems and comparison with other systems using superconductors. p0064 N73 19036
- Features and characteristics of engine fuel control systems and design of synthetic fuel electric generator for airborne use. p0064 N73 19040
- Characteristics of auxiliary power unit combined with a battery drive for auxiliary power system for aircraft electric power supply. p0195 N73 16456
- Design principles of auxiliary power unit for aircraft power system for operation of aircraft equipment. p0065 N73 19046
- Analysis of interface between aircraft mechanical power systems and performance requirements of auxiliary power systems. p0065 N73 19049
- An for research and development program on aircraft electrical power systems to show planning process for developing capabilities of technology. p0066 N73 19052
- Application of solid state switching in aircraft electrical power systems. p0066 N73 19053
- Development of electrical generation and distribution systems for operation of aircraft in ground state switching and remote control of power line devices. p0066 N73 19054

- Development of integrated control system for supersonic aircraft based on pneumatic power operation. p0056 N73 19056
- Structural components of rotary wing systems capabilities to show a larger understanding of specific vertical takeoff aircraft components. p0048 N73 21021
- Economic analysis of integrated time frequency systems for aircraft. p0235 N73 23717
- Analysis of integrated communications navigation and identification system for aircraft operation and proposal for improved capability. p0236 N73 23721
- Markings for propeller construction. p0057 N74 12713
- [AGARD AR 56] p0057 N74 12713
- Aircraft aerial system testing and evaluation in the United Kingdom. p0237 N74 14352
- The application of new principles on cockpit tasks and equipment to flight safety research. p0107 N74 18802
- Technical and operational aspects of externally mounted aircraft equipment. p0305 N74 21614
- ### AIRCRAFT FUELS
- Aircraft fuels, lubricants and fire safety conferences. [AGARD CP 80-71] p0251 N72 11668
- Small scale combustion characteristics for combustion characteristics determination of aviation fuel. p0251 N72 11674
- Dual purpose filter separators for dirt and water removal from fuel. p0252 N72 11676
- Fire related problems in aircraft fuel systems, emphasizing hydrogen treated fuel. p0252 N72 11677
- Theoretical analysis of fire spread by fuel properties and quantities delay time as function of temperature and width of hot gas region. p0252 N72 11683
- Fire extinguishing system in aircraft using stages of solid propellant gas generator to pressure extinguish bottles. p0253 N72 11685
- Electrostatic charging in handling of aviation fuels as function of base sparking voltage. p0253 N72 11686
- Crash safe fuel line program for winged jets. p0253 N72 11687
- Post crash fire safety of helicopter turbine engine fuels. p0253 N72 11688
- Simulated fire tests to assess the resistance of aircraft fuel containing chemical additives. p0254 N72 11692
- Use of fluoropolymer surfaces to extinguish aircraft fuel fires. p0254 N72 11693
- International survey of air pollution by aircraft engines and fuels. p0217 N72 21590
- [AGARD AR 40] p0217 N72 21590
- Discussion of aircraft fuels and lubricants to indicate problems, analysis, testing and fire safety. p0255 N72 21811
- [AGARD AR 44] p0255 N72 21811
- ### AIRCRAFT GUIDANCE
- Feasibility evaluation of microwave aircraft digital guidance equipment for helicopter approach and landing guidance system. p0034 N72 11936
- Software and hardware technology for application of computer systems to guidance and control of aerospace vehicles. p0155 N72 21211
- [AGARD OGRAPH 158] p0155 N72 21211
- Hardware organization and system design of guidance and control computers. p0155 N72 21214
- Programming characteristics of logic guidance and control computers. p0156 N72 21216
- Fast rotation algorithms for general purpose digital computer used in guidance and control applications. p0156 N72 21220
- Guidance and control computer related display system technology. p0156 N72 21221
- General digital computers for helicopter guidance and control systems. p0156 N72 21223
- Application of airborne digital computers to local, C-0 and Omega navigation and guidance systems. p0157 N72 21225
- Selection of computers for satellite based navigation and guidance system designed for aircraft use. p0157 N72 21226
- Digital computers for navigation and guidance systems and fire control systems in tactical aircraft. p0157 N72 21227
- Design guide lines for partial integrated flight control and guidance displays for V-STOL aircraft. p0224 N72 22630
- [NASA CR 126153] p0224 N72 22630
- Organization and operation of a control area traffic control system and development of improved equipment for local, area and regional. p0232 N73 23691
- Characteristics of an aircraft control system to include design of the three components and process for developing proposed equipment. p0232 N73 23692
- Development of automated traffic control system using computer techniques to provide flight safety for congested air traffic. p0232 N73 23693
- Organization, functions and applications of a distributed aircraft control system for future flight. p0232 N73 23694
- Design of the two dimensional traffic control system and development of automated techniques for increasing flight safety. p0233 N73 23696
- Design of an air traffic control system for a future aircraft for a future aircraft system configurations. p0233 N73 23697
- Development of optical traffic control system for an aircraft in the future. p0233 N73 23698

- Analysis of short takeoff and landing aircraft landing guidance systems and application of aircraft control procedures for improved sequencing. p0233 N73 23700
- Development and characteristics of instrument landing system using radio line materials along ways for glide slope and alignment information. p0234 N73 23707
- Development and characteristics of forward area homing and landing guidance for military aircraft operations. p014 N73 23709
- Application of aircraft satellites for data acquisition and communication functions in air traffic control system. p0234 N73 23709
- Development and characteristics of system for separation and control of aircraft to avoid mid-air collisions. p0235 N73 23710
- Performance tests of air traffic control system to determine effectiveness in prevention of mid-air collisions. p0235 N73 23712
- Analysis of man-machine interfaces and system reliability for air traffic control automation systems. p0235 N73 23715
- Analysis of interface between controller and computer in automated air traffic control system. p0235 N73 23716
- Analysis of development programs for improving US air traffic control procedures for 1980 time period. p0235 N73 23718
- General analysis of improved communication techniques for instrument landing system for military applications. p0235 N73 23719
- Analysis of communications navigation and identification equipment for aircraft and proposed system for implementation feasibility. p0236 N73 23720
- ### AIRCRAFT HAZARDS
- Safety measures to eliminate aircraft landing vortex hazards. p0026 N71 23418
- [NASA TM X 67125] p0026 N71 23418
- Exhaust gas flames and fires on aircraft. p0252 N72 11680
- Flammability properties of jet fuels and its hazards for fire and explosion suppression in simulated hostile operating environment conditions. p0252 N72 11681
- Various gelled or emulsified fuels for reducing aircraft crash fire hazard. p0252 N72 11689
- ### AIRCRAFT INDUSTRY
- Survey and analysis of application of destructive inspection methods to aircraft structures. p0197 N72 19541
- [AGARD P 587-71] p0197 N72 19541
- Aircraft industry survey for analysis of nondestructive inspection methods application to commercial aircraft for 1980 to 1990. p0197 N72 19543
- ### AIRCRAFT INSTRUMENTS
- Guidance and control display design for aircraft and spaceflight mode. p0223 N72 22621
- [AGARD CP 96] p0223 N72 22621
- Tradeoffs between manual and computer control in aircraft display and experiments involving immediate response to long task response and time judgment. p0223 N72 22623
- Criteria for elements of multi-processor aircraft display to assist mission in mode of structure of read-out. p0223 N72 22624
- Integrated cockpit research project used to study cockpit and display requirements in advanced aircraft. p0223 N72 22625
- Prediction and measurement of cockpit workload for pilot performance and system design analysis for pilot workload and limitations. p0223 N72 22626
- Assessment of design aircraft cockpit layout and display control system. p0224 N72 22629
- Avionics map display systems using direct view projected phosphor CRT and electronic integrated map displays. p0224 N72 22634
- Electronic head up display systems for military aircraft. p0225 N72 22635
- Engineering and operational factors of electronic instrument aircraft displays. p0225 N72 22636
- Spacecraft display technology application to aircraft guidance and control displays. p0225 N72 22641
- Flight test data and electronic display of flight test data panel in aircraft cockpit. p0226 N72 22644
- Design of aircraft flight test instrument systems. p0195 N73 16457
- Analysis of aircraft instruments and display devices for approach control and landing of V-STOL aircraft. p0196 N73 16459
- [AGARD AR 51] p0196 N73 16459
- Development of head up display data display for aircraft approach and landing with altitude and heading. p0233 N73 23700
- Economic analysis of integrated time frequency system for aircraft. p0235 N73 23717
- ### AIRCRAFT LANDING
- Influence of various operational factors on aircraft approach, landing and accuracy. p0226 N71 22641
- Speed and field length safety factors for approach and landing in the presence of wind. p0228 N71 23420
- Systems performance and safety in helicopter approach and landing and takeoff from guidance area. p0234 N72 11699
- V-STOL display requirements for approach and landing in the presence of wind. p0224 N72 22640
- Multiple use wide field of view displays of terrain. p0224 N72 22641
- Display for aircraft pilots during approach and landing and other area views in low altitude changes. p0224 N72 22644

## SUBJECT INDEX

## AIRCRAFT PILOTS

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

### AIRCRAFT PERFORMANCE

## AIRCRAFT PRODUCTION

Nondestructive tests applied to quality control of airframes made of boron composites p0290 N72 24936  
 AGARD Annual Meeting, 1973: conference on research and development in France and use of science and technology to meet military requirements at reduced costs p0304 N74 21610  
 Techniques oriented towards cost reduction in aircraft production p0305 N74 21613  
 Research work and costs: the role of data processing in aircraft production p0305 N74 21617  
 Impact of technology on cost reduction in aircraft production p0305 N74 21618

## AIRCRAFT RELIABILITY

Physical vulnerability of aircraft: volume 1 [AGARD AR 47 VOL 1] p0061 N74 73500  
 Physical vulnerability of aircraft: volume 2 [AGARD AR 47 VOL 2] p0061 N74 73501  
 Aircraft vulnerability analysis: volume 3 [AGARD AR 47 VOL 3] p0061 N74 73502  
 Helicopter design for improving crash survivability of aircraft and occupants p0101 N72 79141  
 Reliability design of manned supersonic aircraft: considerations of safety hazards p0178 N73 23883

## AIRCRAFT SAFETY

Accident investigations: flight control systems and operational recordings for improved aircraft flight mechanics [AGARD CP 76 71] p0027 N71 23410  
 Operational flight data analysis for improved aviation safety levels p0027 N71 23411  
 Onboard data acquisition for improved aircraft design and operational flight safety p0027 N71 23412  
 Operational performance and handling safety requirements for single engine boundary layer controlled aircraft: STOL mode p0028 N71 23419  
 Human factors and safety requirements in aircraft design p0029 N71 23423  
 Systems performance and safety in helicopter approach and landing and radioelectronic guidance array p0034 N72 11939  
 Stability and control systems for advanced aircraft flight mechanics and safety [AGARD AR 48] p0041 N73 13018  
 Procedures for evaluating fatigue quality of aircraft structures based on fatigue life, crack propagation and residual strength p0294 N73 29925

## AIRCRAFT SPECIFICATIONS

Design development and requirements for short takeoff transport aircraft for military applications using civil aircraft production procedures p0055 N72 27011  
 Analysis of research and development programs involving construction of the short takeoff transport aircraft in Germany p0055 N73 27013

## AIRCRAFT STABILITY

Wind tunnel studies of external store induced flow field instability effects on longitudinal stability of arrow wing aircraft p0005 N71 19382  
 Proceedings of conference on aircraft flight test procedures: data acquisition, data processing and correlation with wind tunnel test results [AGARD CP 85] p0034 N72 20976  
 Flight test procedures for determining stall and spin characteristics of high performance aircraft p0035 N72 20979  
 Stability and control: flight test procedures for V-STOL aircraft in general and specific applications to P-1127 and Harrier aircraft p0036 N72 20980  
 Analysis of factors affecting lateral-directional handling qualities of aircraft during short takeoff flight p0040 N72 32033  
 Analysis of methods for predicting aircraft performance and recommendations for computer programs to provide accurate prediction capability p0040 N72 32036  
 Inflight variable stability: airplane investigations using corner approaches to determine effect of dynamic pressure parameters on aircraft performance p0040 N72 32037  
 Review of research projects on aircraft handling qualities: vehicle stability and control characteristics p0040 N72 32038  
 Survey of aerospace industry to determine various techniques used in considering interactions of handling qualities, stability, control and load alleviation devices on structural loads [AGARD H 593] p0040 N73 11029  
 Stability and control systems for advanced aircraft flight mechanics and safety [AGARD AR 48] p0041 N73 13018  
 Summaries of papers presented in conference concerning aircraft stability and control [AGARD CP 119] p0043 N73 13989  
 Relationship between mission requirements of piloted aircraft stability and maneuverability p0044 N73 16995  
 Design criteria for satisfactory stability and control of military aircraft p0044 N73 16996  
 Prediction of aerostatic change moment effects on stability and control p0045 N73 17000  
 Influence of power distribution on stability and maneuverability p0045 N73 17008  
 Artificial stabilization to correct control deficiencies for high performance aircraft p0045 N73 17009  
 A simple method for determining stability and control derivatives from flight data p0045 N73 17012

Handling characteristics of V-STOL aircraft based on data obtained from flight tests, simulator operation and analytical studies [AGARD R 577 PT 2] p0055 N73 27906

The problem of installing a modern high bypass engine on a twin jet transport aircraft p0021 N74 14727  
 Experience with a low altitude turbulence model for aircraft certification: correlation of gust model data with statistical analysis of flight test results p0059 N74 17738  
 CSAS design for good handling in turbulence: development of design criteria for stability augmentation systems for alleviation of gust effects p0059 N74 17774  
 Theoretical horizontal tail loads and associated aircraft responses of an autopilot controlled jet transport flying in turbulence: analysis of problem areas associated with rigid aircraft controlled by simple autopilot p0059 N74 17742

The design of automatic flight control systems to reduce the effects of atmospheric disturbances: flight tests of experimental automatic pilots on BAC 111 aircraft p0060 N74 17743

## AIRCRAFT STRUCTURES

Aerodynamic interference characteristics of airframe-propulsion systems of transport and military aircraft [AGARD CP 71 71] p0001 N71 19353  
 Optimization of interferences between aircraft components in supersonic flow p0001 N71 19356  
 Three dimensional interactions in half cone pressure fields and effects on intakes mounted adjacent to aircraft fuselage p0003 N71 19367  
 Transfer functions in modelling human pilot and dynamic structural aircraft responses [AGARD R 580 71] p0006 N71 23210  
 Mathematical modelling of aircraft structural response modes to active control system p0007 N71 23212  
 Computation and measurements of dynamic aircraft transfer functions to atmospheric turbulence p0007 N71 23213  
 Survey and analysis of application of nondestructive inspection methods to aircraft structures [AGARD H 587 71] p0197 N72 19541  
 Stress corrosion cracking in aircraft structures and various materials: historical review p0285 N72 21901  
 Survey and analysis of literature on fatigue damage accumulation in aircraft materials and structures [AGARD AG 157] p0290 N72 22918  
 Conference on Structural Applications of Advanced Composites [AGARD CG 55] p0209 N72 23509  
 Composites in structural design process p0209 N72 23592  
 Primary and secondary structural applications of advanced composites p0210 N72 29596  
 Analysis of aircraft structural flexibility and flight control interferences with application to aircraft design criteria p0039 N72 32031  
 Calculating eigenfrequencies, modes and generalized masses for F-104G aircraft from drawings by finite element method [AGARD R 592] p0240 N72 33915  
 Random load fatigue of aircraft structures: conference [AGARD CP 118] p0291 N73 16896  
 Fatigue life assessment of aircraft structures based on random or programmed fatigue tests and loadings p0291 N73 16897  
 Physical aspects of fatigue damage accumulation: including interaction and sequence effects p0291 N73 16899  
 Parametric and nonparametric techniques for aircraft design: synthesis to show principal effects of flow for composite development p0050 N73 24049  
 Use of reinforced boron and carbon fiber composites in aircraft structures p0211 N73 27484  
 Construction of glider aircraft using glass fiber and carbon fiber reinforced plastic composite materials for weight reduction and increased strength p0211 N73 27486  
 Application of composite materials and sandwich structures to reduce vulnerability of aircraft structures to projectile impact p0212 N73 27487  
 Design and manufacturing of composite materials with organic matrices for use in aerospace vehicle structures subjected to high temperatures p0212 N73 27489  
 Development of fiber reinforced composite materials for application in air breathing engines, propeller vehicles, and spacecraft components p0212 N73 27491  
 Summaries of papers presented in AGARD conference on random load fatigue [AGARD AR 54] p0292 N73 28884  
 Analysis of response of fatigue in the activation of light aircraft fatigue machine: plates with emphasis on a just fatigue property p0292 N73 29972  
 Methods for determining aircraft structural response to acoustic fatigue p0293 N73 29913  
 Structural response and endurance tests of aircraft structural components to determine effect of noise at given mission on acoustic fatigue p0294 N73 29920  
 Application of stress test techniques for determining response and life of aircraft structures subject to engine noise field excitation p0294 N73 29922  
 Development of experimental program for determining response and life of fatigue resistance of lightweight aircraft structures p0294 N73 29923

Development of procedures for predicting fatigue life of aircraft structures based on fracture mechanics, crack propagation and residual static strength analysis [AGARD LS 62] p0294 N73 29924

Procedures for evaluating fatigue quality of aircraft structures based on fatigue life, crack propagation and residual strength p0294 N73 29925  
 Procedures for predicting fatigue life of aircraft flying under various load conditions using data obtained by counting accelerometer p0294 N73 29927  
 Optimization of aircraft structures with multiple stiffness requirements p0297 N74 15612  
 Structural fatigue analysis and testing for fighter aircraft p0060 N74 19655

## AIRCRAFT SURVIVABILITY

Application of composite materials and sandwich structures to reduce vulnerability of aircraft structures to projectile impact p0212 N73 27487

## AIRCRAFT WAKES

Comparison of various methods for calculating profile drag from pressure measurements in the near wake at subcritical speeds p0020 N74 14721  
 The detection of aircraft wake vortices: development of acoustic and wind pressure sensors for vortex detection p0058 N74 17731  
 Wake Vortex Avoidance System program (WVAS): design and implementation of ground based monitoring and predictive system for safety from wake vortices p0058 N74 17732  
 Vortex wake research: inflight investigation of turbulent wake generated by C-5 aircraft p0058 N74 17733

## AIRFOIL PROFILES

Design characteristics and performance of airfoils with high lift at low and medium subsonic speeds and various angles of attack p0042 N73 15004  
 Effect of rotary wing airfoil modifications on performance, stability and control of helicopters p0051 N73 21045

## AIRFOILS

Aerodynamic effects of mechanical high lift devices on conventional airfoils p0025 N71 20052  
 Two dimensional wind tunnel tests on airfoils with high lift devices p0025 N71 20056  
 Representations of flow separation bubbles near airfoil leading edge p0027 N71 20064  
 Flow model for shock induced leading edge transition: flow turbulence and rear separation in a speed stall of airfoil p0111 N72 11858  
 Equivalent body of revolution for simulating high Reynolds number effect on transonic flow past two dimensional airfoil p0014 N72 11874  
 Development of two experimental approaches for analyzing two dimensional flow on high lift devices p0042 N73 15005  
 Analysis of aerodynamic processes occurring in flow past unpurged multi element airfoils in high lift attitude p0042 N73 15007  
 Analysis of aerodynamic stall characteristics of wing sections with high lift devices in two dimensional flow p0042 N73 15008  
 Development of procedure for determining characteristics of high lift systems where viscous effects dominate p0042 N73 15009  
 Aerodynamic configurations of swept wings to improve lift performance at stall in higher range of subsonic speeds p0042 N73 15010  
 Calculation and measurement of aerodynamic forces on oscillating airfoil with and without aerodynamic damping p0050 N73 21042  
 Generation of aerodynamic noise by turbulent wake behind rotary wing airfoil and relationship to drag at different conditions p0052 N73 21054  
 Effects of aeroelasticity on performance of rotary wings and procedures for predicting aerodynamic forces on rotary wing blades p0057 N73 22952  
 Remarks on methods for predicting various drag aerodynamic drag prediction for high angles of attack and multielement airfoils p0020 N74 14718  
 Transonic drag due to lift of planar jet flapped airfoils p0020 N74 14720

## AIRFRAME MATERIALS

Properties and selective applications of high strength steels, aluminum and titanium alloys, polymeric materials, ceramic materials and composite materials in aerospace engineering [AGARD LS 51 71] p0205 N73 21038  
 Properties and selective applications of titanium alloys in engine construction p0206 N73 21044  
 Properties and selective applications of titanium alloys in airframes and jet engines p0206 N73 21045  
 Comparing characteristics of advanced composites with those of conventional aircraft materials p0210 N72 29595  
 Primary and secondary structural applications of advanced composites p0210 N72 29596  
 Metallurgical aspects of fatigue and fracture toughness: consideration of effects of microstructure on mechanical properties of aircraft materials [AGARD R 610] p0294 N73 29920  
 The main aspects of fatigue in the design of aircraft: stress effects on structural materials at properties of advanced aircraft materials p0294 N73 29923



Development of multi-beam antenna system and computer switch for producing variable coverage radiation pattern for satellite communication system. p0193 N72 19507

Facilities and techniques for measuring antenna radiation patterns of spacecraft in ground and telecommand antenna. p0194 N72 19512  
Characteristics of directional dipole antennas for low frequency radio interferometer. p0134 N73 10213  
Introductory lecture: Target scattering characteristics of importance to radars. p0144 N74 11955  
Introductory survey to session 3: Control of antenna side lobes. p0147 N74 11957

# ANTHROPOMETRY

Anthropometry and medical evaluation of pilots. p0074 N72 25055  
Anthropometry for protective equipment evaluation and human impact acceleration experiments. p0084 N73 23066

# ANTI-FRICTION BEARINGS

Development of spherical hydrostatic compliant bearing for directional gyroscope. p0229 N73 20895

# ANTI-GRAVITY

Negative g strap for restraint and performance during aircraft acrobatics, vibration and crash impact. p0104 N72 19158

# ANTISUBMARINE WARFARE

Evaluation of the role of the simulator in training airborne ASW operations. p0107 N74 18801

# ANXIETY

Relationship of interaction of sleepiness and anxiety to perceptual motor performance in human beings. p0069 N71 20361

# APOLLO SPACECRAFT

Computerized Apollo spacecraft attitude control system. p0278 N72 12870

# APOLLO 16 FLIGHT

BIOSTACK experiment on Apollo 16 for studying combined action of heavy high-energy dust, solar and spare light factors on resting biological systems. p0183 N73 23062

# APPLICATIONS OF MATHEMATICS

Relative graphical and simplified mathematical treatment of rotational dynamics is applied to human centrifuge. p0094 N71 23340

# APPROACH

System performance and safety in helicopter approach and landing. p0034 N72 11939

STOL display, requirements for approach and landing under adverse weather conditions. p0224 N72 12632  
Multiple approach and landing displays on a head up display for pilots during approach and landing and other maneuvers involving altitude changes. p0225 N72 12633

Analysis of helicopter approach and landing displays in simulating carrier landings and takeoffs indicated by display resolution temporal fading and motion clarity. p0115 N72 12643

Rate of change of performance monitoring parameter during approach and landing. p0126 N72 12643  
The effect of gusts and wind shear for a dynamic STOL approach and landing: simulation and flight test of flight control system for short takeoff aircraft. p0058 N74 17730

# APPROACH CONTROL

Speed and fuel flight safety factors for approach and landing in the vicinity of Bagdad airport. p0029 N71 23129  
Aircraft approach and approach control in the vicinity of a river valley. p0029 N71 23129

Method for relating weather conditions to small size to determine minimum instrument approach heighting requirements for multi-engine aircraft. p0031 N72 11913  
Automatic approach and hover computer for use in helicopters. p0032 N72 11924  
Inductive variable stability airplane investigations during carrier approach to determine effect of flying qualities parameters on approach performance. p0340 N72 22017

Analysis of aircraft instruments and display devices for approach control and landing of STOL aircraft. p0190 N73 18439  
[AGARD AR 31]

# APPROACH INDICATORS

Automatic approach and landing system with flight warning system for Caravelle aircraft. p0130 N71 23429

# APPROXIMATION

Approximation of pressure distribution on a blunt body configurations at subsonic and supersonic speeds. p0093 N71 19164  
Approximation of two-dimensional flow field boundary layer under arbitrary wall and flow conditions. p0176 N72 20276  
Numerical approximation of flow fields for flow fields systems in hydrodynamics. p0181 N72 21275  
Three approximation methods for the Navier-Stokes equations for two and three dimensional steady flow. p0183 N72 21276

# APTITUDE

Genetic aptitude test techniques for the aviation and pilots. p0181 N72 19164  
Personality traits and flight aptitude. p0181 N72 19164

# AQUEOUS SOLUTIONS

Dielectric stress, conductivity, and dielectric propagation characteristics of high strength, stress, and dielectric environment. p0281 N72 22913

# ARCTIC REGIONS

Models of Arctic ionosphere. p0128 N72 21123

Arctic ionogram sequences and auroral oval. p0176 N72 21125

Effects of Arctic ionosphere characteristics on radio and radar propagation. p0130 N72 22136  
[AGARD AR 33]

# AREA NAVIGATION

Comparison of cost complexity and cockpit workload for seven area navigation system configurations. p0233 N73 23697

Characteristics of airborne area navigation equipment and application to air traffic control functions. p0233 N73 23698

Development of high bandwidth time division communications system to provide ground based wide area position location system. p0234 N73 23711

# ARMED FORCES

Stresses and adaptation problems associated with large scale long range rapid reaction time aerial troop deployments. p0069 N72 20360

# ARMED FORCES (FOREIGN)

Oxygen consumption and work capacity in fitness evaluations on Canadian Armed Forces personnel. p0092 N71 22311

Clinical causes for permanent grounding of German Armed Forces flying personnel. p0096 N72 14097  
Neurophysiologic and other causes for permanent grounding of French Air Force flying personnel. p0096 N72 14098

Ten year analysis of medical factors in flying and flight training in Great Britain. p0096 N72 14099

Description of routine cardiology program to determine flight fitness for German Air Force. p0097 N72 14102

Long term electrocardiograms in analysis of rhythmic heart disturbances of German Air Force. p0097 N72 14103

Physiological factors possibly contributing to coronary risk among German Air Force pilots. p0097 N72 14104

Naval and aerial disorders and flight fitness in German Armed Forces. p0097 N72 14107

Ophthalmologic reasons for grounding pilots of German Air Force. p0097 N72 14108

Psychiatric reasons for permanent grounding of flight crew members in Royal Air Force. p0098 N72 14110

Psychological factors in pilot grounding in German Air Force. p0098 N72 14111

Psychological requirements for German Air Force pilots. p0097 N72 14103

Color vision requirements of Canadian Armed Forces, including their standard tests. p0077 N73 19070

Color vision requirements of Great Britain's Armed Forces. p0077 N73 19072

Operational performance of helicopters in French Army. p0046 N73 21011

Physiological method for selecting and observing student pilots in Belgian Air Force for aviation careers. p0079 N73 21099

Selection of student pilot candidates of the Belgian Air Force by psychomotor tests. p0088 N74 18788

# ARMED FORCES (UNITED STATES)

U.S. Army helicopter requirements in Vietnam and future helicopter requirements and developments. p0030 N72 11916

Role of flight surgeons and physicians in evaluation and treatment of jet fighter pilots. p0095 N72 14094

Trends and factors relating to a pilot's causes for grounding from based on USAF School of Aerospace Medicine experience. p0036 N72 14095

Medical and aviation management and medical emergency in relation to Air Force flight personnel. p0096 N72 14096

Operational and medical cases reviewed by Navy Special Board of Flight Surgeons. p0096 N72 14100

Candidate selection as a factor in evaluating flight fitness of Air Force personnel. p0096 N72 14101

Factors in medical suspensions of Air Force flying personnel. p0097 N72 14105

Effects of 10 days of hypoxia during ejection extraction in USAF. p0102 N72 19144

Comparison of accident rates among military, civilian and commercial pilots. p0078 N73 19073

# ARMOR

Materials and design of armor for protection. p0102 N72 19143

# ARROW WINGS

Wall effects of flow of water stream and flow field instability effects on the aerodynamic stability of arrow wing aircraft. p0095 N71 19182

# ARTERIO-SCLEROSIS

Atherosclerosis and the hemorheological aspects of aging pilots. p0093 N71 22318

# ARTIFICIAL INTELLIGENCE

Computerized pattern recognition with emphasis on pattern recognition for target identification. p0093 N71 22318  
[AGARD CP 34-71]

Applications of a system for establishing requirements for artificial intelligence in defense and space applications. p0102 N72 19144

Artificial intelligence program for target identification. p0102 N72 19144

Edge detection algorithms: two dimensional Fourier transforms and linguistic methods for computer processing of natural scenes. p0152 N72 11186

Method for automatic recognition and classification of three dimensional objects by their silhouettes. p0152 N72 11188

Interactive graphic techniques for handling pictorial data and applications to pattern recognition and artificial intelligence. p0154 N72 11203

# ARTIFICIAL SATELLITES

Characteristics of attitude control system and onboard computer used with ANS astronomical satellite for ultraviolet and X-ray measurements in space. p0191 N72 19491

Development of Canopus star sensor for stabilization of X4 technology satellite. p0192 N72 19499

High latitude studies of scintillation in radio signals from radio sources and satellites. p0128 N72 21137

Application of artificial satellites for data acquisition and communication functions in air traffic control system. p0234 N73 23709

# ASPECT RATIO

Transonic wind tunnel model measurements of buffer loads and boundaries at various sweep and aspect ratio wing roots. p0016 N72 11886

# ASTHMA

Asthma in military flying personnel. p0085 N74 13792

# ASTRONAVIGATION

Characteristics of sensors for spacecraft attitude determination by reference to earth horizon visible and infrared spectra. p0192 N72 19495

# ASYMMETRY

Coexistence of two dimensional and asymmetric flow in channel with constant cross section. p0207 N72 16716

# ASYMPTOTIC METHODS

Asymptotic expansion techniques to define pressure loading effects on wings with unbalanced control surfaces. p0010 N71 29348

# ATHLETES

Heat tolerance of athletes during muscular exercise in various thermal environments. p0070 N71 20366

# ATLANTIC OCEAN

Total electron content of ionosphere with emphasis on North Atlantic region. p0187 N73 22350  
[AGARD AG 166]

# ATMOSPHERIC ATTENUATION

Conference on atmospheric attenuation and rainfall effects on ultra high frequency telecommunication systems. p0140 N73 26121  
[AGARD CP 107]

Multiple scattering and attenuation of radio signals caused by rainfall. p0140 N73 26122

Ultrahigh frequency coherent radio signal transmission by diffraction phase shift measurements in fog and rain. p0141 N73 26131

Role of atmospheric dusts in the phenomena of interference over large distances. p0143 N73 26139

Measurement of atmospheric attenuation at the frequencies of 15, 19, and 34 GHz: atmospheric effects on microwave transmission. p0149 N74 13870

# ATMOSPHERIC BOUNDARY LAYER

Effects of acoustic gravity wave diffusion in atmospheric boundaries. p0131 N73 14136

Problems in the simulation of atmospheric boundary layer flows in natural wind environment in atmospheric boundary layer wind tunnel and aerodynamic applications. p0057 N74 17722

# ATMOSPHERIC CHEMISTRY

Atmospheric pollution by Aircraft Engines. p0217 N74 14271  
[AGARD CP 125]

Retention of NO<sub>x</sub> formations by premixing. p0217 N74 14272

United States Department of Transportation research program for high altitude pollution. p0217 N74 14273

Reactions of organic nitrogen oxides at high altitudes. p0217 N74 14274

Atmospheric nuclear weapon testing: climate and atmospheric ozone. p0217 N74 14275

Photo oxidation of aircraft engine emissions at low and high altitudes. p0218 N74 14277

Chemical kinetics in the stratosphere: atmospheric composition and atmospheric chemistry based on photochemical reactions. p0218 N74 14279

Relative air pollution emissions from aircraft in the UK and neighbouring states. p0218 N74 14282

# ATMOSPHERIC CIRCULATION

Mathematical model for acoustic gravity wave excitations moving in the stratosphere. p0214 N73 14135

Problems in the simulation of atmospheric boundary layer flows: natural wind environment in atmospheric boundary layer wind tunnel and aerodynamic applications. p0057 N74 17722

Review of data on tropospheric temperature profiles and atmospheric surface observations: summary of a report of the Joint Committee on the Troposphere. p0057 N74 17724

# ATMOSPHERIC COMPOSITION

Ultrahigh resolution solar far wing refractive index structure of the troposphere. p0123 N72 16101

Characteristics of electronically operated transmitters for satellite applications and analysis of atmospheric data acquisition. p0192 N72 19494

Design engineering for radio communication systems involving tropospheric scatter propagation. p0141 N73 26128

## AUTOMATIC CONTROL

Independent variables height and fading statistics for A-S  
5 weighting frequency signal transmission to each

Ultra-high frequency hospital. Alligation measure  
ingly by ATS 5 weather radar and radometer:

### ATTACK AIRCRAFT

Application of cluster rotation to improvement of existing platform's strike aircraft: p0230 A73 20704

## ATTENUATION

Synthesis of passive filters with infinite attenuation points realized with weak noise components applied to high degree Euler filters. p0167 N74 13923

## ATTITUDE (INCLINATION)

Durnal variations in ionospheric tilt near magnetic dip  
equator due to gravity waves. R0138 N73 14160

Computerized App:

Testing of an attitude control unit in sounding rockets  
p0276 N72 14749

## ATTITUDE CYCLES

level grade instrumentation for precision structural  
reference system. (0229 N73 20699)

### ATTITUDE STABILITY

**AUDITORY DEFECTS**

**Pure line strains:**

\*Annual costs for the sequence of the 10th generation are shown.

### test

**AUDITORY PERCEPTION**  
A. Dornes - evaluation of young pilot's hearing ability  
relative to flying time. p00933 571 2232

## AUDITORY STIMULI

File is all right for a response to a delivery threat and is  
 100% correct.

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific information required.

Effects of x-ray on the vesicular system of quail  
eggs and embryos

## AURORAL ARCS

Acoustic surface shock wave generation by supersonic jet

## AURORAL ELECTROJETS

00135 473 1413

Other values of  $\omega$  and  $\gamma$  are shown in Fig. 1.

**AURORA IONIZATION**

Forward and backward  
and a total of 1000

10126 472 2112

AURORAS

$$A = I + \frac{1}{\alpha} \nabla^2 - Q^{-1} \Delta^{(0)}.$$

Approved and attested for signing at New York, New York  
this 12th day of August 1964 by the following members:

VIII. 10314<sup>2</sup>, (A. 1972)

14-00000

17. A. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 8

DATE SUBMITTED: 01/29/95  
 01/29/95 2:15  
 (last name, first name, initial)

$$1.45 \times 10^4 \times 6.830 \times 10^{-4}$$

for acoustic waves in a metal plate and radio waves in a plasma (p.127-132, 211).

[illegible]

Received 12 October 1993; accepted 12 November 1993

$$H_{\infty}(V) = H_{\infty}(V^{\text{cl}}) \oplus H_{\infty}(V^{\text{cl}})^{\perp} = 0 \oplus 0 = 0$$

Spiegel et al. / *Exploring the Potential of Absolute Scale* 129

1997-1998

14. *Journal of the American Medical Association*, 261:1271-1274 (1989)

## AUTOMATA THEORY

$$y = \frac{1}{\sqrt{\pi}} \exp(-x^2) \quad \text{and} \quad y = \frac{1}{\sqrt{\pi}} \exp(-x^2) \cdot \log(1+x^2)$$



- Automatic analysis of ECG at rest during and after exercise with two computer systems p0073 N72 25052
- Techniques for control and guidance of tactical missiles with emphasis on cost, reliability and performance [AGARD LS 52] p0226 N72 27681
- Numerical analysis of adjoint equations yielding error sensitivities in linear systems applied to guidance and control of tactical missiles p0226 N72 27684
- Automated technique control system for military communications facility p0133 N73 1040
- Organization, functions and capabilities of automated air traffic control system for Rome, Italy p0232 N73 23694
- Feasibility of automated spacecraft monitoring using real time computer telemetry p0279 N73 23888
- Tactical integrated electronic systems for Swedish military aircraft p0279 N73 23889
- Computerized simulation of multistop altitude control system for satellite with flexible booms p0279 N73 23890
- Exponential probability distribution analysis for extrapolating aerospace system performance statistics from test results p0281 N73 23923
- A research workers view on the future of automatic reading machines p0161 N74 16938
- ### AUTOMATIC FLIGHT CONTROL
- Operational performance of Hawker Siddeley aircraft automatic flight approach and landing control system p0028 N73 23414
- Operational performance of automatic V-STOL flight control systems using jet thrust or air bleed p0028 N73 23415
- Human factors and control system failures in jet upsets during turbulence encounters p0029 N73 23424
- Some problems in developing automatic flight control systems for light helicopters p0031 N72 11922
- Automatic approach and hover computer for reactive helicopters p0032 N72 11926
- Onboard computers for automatic control of manned aerospace systems considering human factors integration [AGARD CP 114] p0278 N73 23881
- Computerized stateless guidance system for aircraft flight control p0280 N73 23895
- Design of aircraft digital system for automatic flight control p0281 N73 23900
- ### AUTOMATIC LANDING CONTROL
- Operational performance of Hawker Siddeley aircraft automatic flight approach and landing control system p0028 N73 23414
- Automatic approach and landing system with flash warning signal for Caravelle aircraft control p0030 N73 23429
- Experience with a low altitude turbulence model for autoland certification: correlation of gust model data with statistical analysis of flight test results p0059 N74 17739
- ### AUTOMATIC PILOTS
- Breakdown of automatic pilots on auxiliary stabilization systems on helicopters p0031 N72 11916
- Theoretical horizontal tail loads and associated aircraft responses of an autopilot controlled jet transport flying in turbulence: analysis of problem areas associated with rigid aircraft controlled by simple autopilot p0059 N74 17742
- The design of automatic flight control systems to reduce the effects of atmospheric disturbances: flight tests of experimental automatic pilot on BAC 111 aircraft p0060 N74 17743
- ### AUTOMATION
- Development of automated traffic control system using computer techniques to provide flight safety for mixed air traffic p0032 N73 23493
- Analysis of terminal area traffic control procedures to determine impact of automation on air traffic controller performance p0033 N73 23499
- ### AUTOMOBILE ACCIDENTS
- Airbag: death belt analysis as restraint in passenger cars European car collisions p0099 N72 19139
- Structural crashworthiness performance of car collision at automobile and performance of structural devices designed for protection p0101 N72 19142
- Crash test apparatus for simulation of automobile collisions p0103 N72 19152
- ### AUTOMOBILES
- Restraints for passengers in automobiles p0098 N72 19122
- Crash test system for testing automobiles and impact studies p0103 N72 19151
- ### AUXILIARY POWER SOURCES
- Feasibility of a diesel engine power source for a turbine development of an auxiliary power source for aircraft and missiles [AGARD AR 56] p0063 N73 18091
- Power sources for auxiliary power systems: design and test results [AGARD CP 104] p0063 N73 19039
- Characteristics of auxiliary power units and their use with a turbine engine for auxiliary power systems: a review of the power supply p0063 N73 19040
- Design principles of auxiliary power systems for aircraft power systems for operation of auxiliary power p0063 N73 19041
- Design parameters and testing of auxiliary power systems for aircraft power systems p0063 N73 19042
- Design and characteristics of auxiliary power source to operate electric hydraulic and pneumatic subsystems in ramjet powered aerospace vehicles p0065 N73 19046
- Analysis of interface between aircraft mechanical power requirements and performance requirements of auxiliary power systems p0065 N73 19049
- Analysis of gas turbine engine requirements and performance when main propulsion system furnishes auxiliary power source p0065 N73 19050
- Development of integrated control system for superionic aircraft based on pneumatic power generation p0066 N73 19056
- ### AVALANCHE DIODES
- Generation of superhigh frequency power using negative impedance characteristics of avalanche diodes in reflectron amplifiers p0194 N72 12511
- ### AVIONICS
- Cost effectiveness failure analysis and design techniques for measuring reliability of avionics systems [AGARD LS 47 71] p0169 N71 36776
- Reliability estimation including failure effect analysis of avionics systems p0189 N71 36777
- Effectiveness of reliability programs for avionics equipment p0189 N71 36779
- Cost ownership analysis of avionics equipment p0190 N71 36784
- Proceedings of conference on avionics in spacecraft: covering component technology, instrumentation, satellite subsystems and satellite systems [AGARD CP 87 71] p0 90 N72 19483
- Guidance and control display design for aircraft and spacecraft conference [AGARD CP 96] p0223 N72 22621
- Analysis of aircraft instruments and display devices for approach control and landing of V-STOL aircraft [AGARD AR 51] p0196 N73 18439
- Onboard computers for automatic control of manned aerospace systems considering human factors integration [AGARD CP 114] p0278 N73 23881
- Operational cost and technology development aspects in design of space shuttle avionics systems p0278 N73 23884
- Extended computer language for real time simulation of process control in flight systems p0279 N73 23892
- Serial digital data bus for integrated avionics system interface p0281 N73 23902
- Applications of spread spectrum communications techniques to avionics system p0143 N73 23058
- Advanced test language for avionics systems [AGARD S 54] p0061 N74 22634
- ### AXIAL FLOW
- Aerodynamic characteristics of rotary wings under axial flow conditions and development of numerical analysis techniques p0050 N73 21039
- ### AXIAL FLOW TURBINES
- Design and performance of thermophoton fluid coupled high efficiency temperature axial flow turbine p0260 N71 17339
- Role of boundary layers in axial flow turbomachines and prediction of their effects p0269 N73 19806
- Application of boundary layer forces in turbomachinery p0270 N73 19810
- Prediction of angular wall boundary layers in axial flow turbomachines p0270 N73 19813
- Angular wall boundary layers in axial flow turbomachinery p0270 N73 19814
- ### AXISYMMETRIC BODIES
- Strong interference effects on afterbodies at transonic speeds p0022 N74 14737
- ### AXISYMMETRIC FLOW
- Axisymmetric inlet flow and supersonic theory for gas turbines p0265 N72 16701
- ## B
- ### B 52 AIRCRAFT
- Optimal search release intervals from B 52 aircraft bombing systems p0005 N71 19383
- ### BAC AIRCRAFT
- Autopilot and performance caused by rear fuselage structural loads on BAC aircraft p0004 N71 19375
- ### BAC 111 AIRCRAFT
- The design of an automatic flight control system to reduce the effects of atmospheric disturbances: flight tests of experimental automatic pilot on BAC 111 aircraft p0060 N74 17743
- ### BACK INJURIES
- The risk of musculoskeletal disorders in the workplace: evaluation of work activities p0085 N74 13395
- ### BACKSCATTERING
- Backscatter properties of forest vegetation for radar p0122 N72 16654
- Coherent approach for radar data backscatter from two dimensional surface p0122 N72 16657
- Analysis of radar backscatter from the sea: statistical properties of wavelets and their application to wavelet analysis p0122 N72 16659
- Forward and backscattering caused by wave interaction with a randomization of their effect on radar backscatter p0122 N72 16660
- VHF bistatic CW aerial backscattering and influence of daytime seasonal and geomagnetic latitude p0127 N72 21128
- Radar aureole studies using backscatter radar p0127 N72 21129
- Sweep frequency backscatter radars as detectors of high latitude ionospheric phenomena p0129 N72 21147
- High frequency backscatter observations of high latitude field aligned irregularities in F region p0130 N72 21149
- HF aerial backscatter: scintillation theory and satellite beacon recording p0130 N72 21150
- Narrow and wideband FM CW HF backscatter: observations of radio aureole p0130 N72 21151
- HF measurements of ocean wave directional spectra using Bragg backscatter angle p0148 N74 13867
- ### BALLOON
- Proceedings of symposium on determining requirements and configurations of emergency ejection systems for helicopter crews [AGARD AR 62] p0055 N73 31054
- ### BALL BEARINGS
- Feasibility analysis of solid lubricated ball bearings for aircraft propulsion systems application p0255 N72 11700
- ### BANDWIDTH
- Error probability and bandwidth efficiency in digital transmission channel p0131 N73 10192
- ### BARIUM
- Development of optical striations and Doppler spectrum broadening due to barium plasmas in ionosphere p0128 N72 21136
- ### BAYES THEOREM
- Recursive filters for supervised learning Bayes optimal adaptive pattern recognition with continuous data p0153 N72 11189
- Adaptive and nonadaptive approach to pattern recognition with Bayesian and non Bayesian techniques considered p0153 N72 11190
- ### BEARING (DIRECTION)
- Ionospheric disturbance effects on sky wave bearing measurement p0138 N73 14159
- ### BELGIUM
- Selection of student pilot candidates of the Belg Air Force by psychomotor tests p0088 N74 18788
- ### BENDING
- Response of general laminated plates to applied loads with coupling between bending and extensional modes of deformation p0212 N72 27486
- ### BENDING FATIGUE
- Crack growth tests for determining susceptibility of high strength alloys to stress corrosion cracking p0287 N72 21311
- ### BENDING VIBRATION
- Analysis of helicopter blade flutter for both hinged and hingeless rotor blades [AGARD R 60 71] p0052 N73 21920
- ### BERYLLIUM
- Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials: conference [AGARD CP 63 71] p0206 N72 12492
- Explosive bonding technique for strengthening aluminum with beryllium wires p0208 N72 12502
- Manufacturing of aluminum beryllium composites by hot pressing p0208 N72 12503
- Stress strain fatigue mechanisms of beryllium reinforced aluminum composites having rough or smooth surfaces p0208 N72 12504
- Analysis of stress strain diffusion mechanism between beryllium fiber and aluminum matrix p0208 N72 12507
- ### BERYLLIUM ALLOY
- Analysis of microplasticity of materials used in metal navigation systems to show how stress yield stress and rate of strain hardening in the strain rate region p0278 N73 20692
- ### BIBLIOGRAPHIES
- Gyroscopic theory and applications to inertial guidance and navigation vehicle stabilization and related uses bibliography [AGARD R 58 71] p0189 N71 20092
- Mathematical programming techniques applied to aerospace structural design: algorithmic tools applications and literature review [AGARD AG 149 71] p0283 N71 20128
- Mathematical programming applications to structural design: optimization literature review p0283 N71 20132
- Bibliographies, symposium proceedings, abstracts, stress-strain relationships, creep, fatigue test facilities and associated bibliography [AGARD GRAPH 150] p0094 N71 21337
- Associated bibliography of worldwide bodywork research bibliography p0095 N73 23344
- [NASA TM X 67198] p0095 N73 23344
- ### BINAURAL HEARING
- Normal limits for the sequential binaural hearing audiogram test p0129 N74 20746
- ### BIODYNAMICS
- Biodynamics: a comparative review of literature processes human factors, constraints and limitations and related bibliography [AGARD GRAPH 150] p0094 N73 23337
- Biomechanical and physiological factors in human factors and related bibliography p0095 N73 23342
- Biomechanical and physiological factors in human factors and related bibliography p0095 N73 23343

## BOUNDARY LAYERS

### BOUNDARY LAYER CONTROL

high lift devices extend	p0027 N71 20065
Operational performance and handling safety requirements for single engine boundary layer control aircraft in STO mode	p0028 N71 23419
Wind tunnel model boundary layer reduction through section for a cruise simulation of high Reynolds number full scale aircraft characteristics	p0014 S72 11174
Transient wind tunnel model measurements of buffet levels and pressures at various sweep and aspect ratio wing roots	p0016 S72 11886
Jet blowing for wake bounds layer control in STO aircraft	p0026 S72 10629
Development of two experimental approaches for analyzing flow control flow on high lift devices	p0047 N73 15005
Development of 28 transport aircraft wing and a slotted flap test to show effects of boundary layer fences	

**BOUNDARY LAYER FLOW**  
Coupling effects between wall heating and wall pressure are studied by means of a boundary layer flow.

High speed wind tunnel investigation of  
 [NASA CR 125951] p1179-122 20218

Effect of airframe geometry on rate of  
 formation of day time flow p1179-122 20299

Low speed wind tunnel investigation of turbulent flow  
 in the flow of a streamwise jet p1180-122 20300

Authors of the top papers (ranked by their predicted frequency) are listed in *Working Paper 99-04* (N7) 150(X). Development of the empirical literature applicable to

Development of a new type of analyzing method, dye  
 chromatography, for separating and identifying dye  
 components in dyeing wastewater effluents. (1981)

Effect of village pressure on the response of panels is fully by attached and separated test test force

**BOUNDARY LAYER SEPARATION**  
Flow separation can be made to happen. It can be prevented. It can be delayed. It can be controlled. It can be eliminated. It can be predicted. It can be avoided. It can be prevented. It can be delayed. It can be controlled. It can be eliminated. It can be predicted. It can be avoided.

Flow speed for flows induced leading edge transition from laminar to fully separated flow speed (ft/s)

Analysis of parameters affecting separation and retention of the studied compounds in the studied system (p0041) 93.14995

**Method:** A total of 100 children (three of whom were participants in the previous study) were assigned to one of two groups: a 'control' group and an 'experimental' group.

**BOUNDARY LAYER TRANSITION**  
Boundary layer transition has been studied in flow past a flat plate with a roughness element. *W. J. G. B. De Vries, J. H. J. van der Meer, and J. H. J. van der Meer, J. Appl. Phys., 67(12), 1990, 5723-5730.*

1976-1977, 1978-1979, 1980-1981, 1982-1983, 1984-1985, 1986-1987, 1988-1989, 1990-1991, 1992-1993, 1994-1995, 1996-1997, 1998-1999, 2000-2001, 2002-2003, 2004-2005, 2006-2007, 2008-2009, 2010-2011, 2012-2013, 2014-2015, 2016-2017, 2018-2019, 2020-2021, 2022-2023, 2024-2025, 2026-2027, 2028-2029, 2030-2031, 2032-2033, 2034-2035, 2036-2037, 2038-2039, 2040-2041, 2042-2043, 2044-2045, 2046-2047, 2048-2049, 2050-2051, 2052-2053, 2054-2055, 2056-2057, 2058-2059, 2060-2061, 2062-2063, 2064-2065, 2066-2067, 2068-2069, 2070-2071, 2072-2073, 2074-2075, 2076-2077, 2078-2079, 2080-2081, 2082-2083, 2084-2085, 2086-2087, 2088-2089, 2090-2091, 2092-2093, 2094-2095, 2096-2097, 2098-2099, 2100-2101, 2102-2103, 2104-2105, 2106-2107, 2108-2109, 2110-2111, 2112-2113, 2114-2115, 2116-2117, 2118-2119, 2120-2121, 2122-2123, 2124-2125, 2126-2127, 2128-2129, 2130-2131, 2132-2133, 2134-2135, 2136-2137, 2138-2139, 2140-2141, 2142-2143, 2144-2145, 2146-2147, 2148-2149, 2150-2151, 2152-2153, 2154-2155, 2156-2157, 2158-2159, 2160-2161, 2162-2163, 2164-2165, 2166-2167, 2168-2169, 2170-2171, 2172-2173, 2174-2175, 2176-2177, 2178-2179, 2180-2181, 2182-2183, 2184-2185, 2186-2187, 2188-2189, 2190-2191, 2192-2193, 2194-2195, 2196-2197, 2198-2199, 2200-2201, 2202-2203, 2204-2205, 2206-2207, 2208-2209, 2210-2211, 2212-2213, 2214-2215, 2216-2217, 2218-2219, 2220-2221, 2222-2223, 2224-2225, 2226-2227, 2228-2229, 2230-2231, 2232-2233, 2234-2235, 2236-2237, 2238-2239, 2240-2241, 2242-2243, 2244-2245, 2246-2247, 2248-2249, 2250-2251, 2252-2253, 2254-2255, 2256-2257, 2258-2259, 2260-2261, 2262-2263, 2264-2265, 2266-2267, 2268-2269, 2270-2271, 2272-2273, 2274-2275, 2276-2277, 2278-2279, 2280-2281, 2282-2283, 2284-2285, 2286-2287, 2288-2289, 2290-2291, 2292-2293, 2294-2295, 2296-2297, 2298-2299, 2300-2301, 2302-2303, 2304-2305, 2306-2307, 2308-2309, 2310-2311, 2312-2313, 2314-2315, 2316-2317, 2318-2319, 2320-2321, 2322-2323, 2324-2325, 2326-2327, 2328-2329, 2330-2331, 2332-2333, 2334-2335, 2336-2337, 2338-2339, 2340-2341, 2342-2343, 2344-2345, 2346-2347, 2348-2349, 2350-2351, 2352-2353, 2354-2355, 2356-2357, 2358-2359, 2360-2361, 2362-2363, 2364-2365, 2366-2367, 2368-2369, 2370-2371, 2372-2373, 2374-2375, 2376-2377, 2378-2379, 2380-2381, 2382-2383, 2384-2385, 2386-2387, 2388-2389, 2390-2391, 2392-2393, 2394-2395, 2396-2397, 2398-2399, 2400-2401, 2402-2403, 2404-2405, 2406-2407, 2408-2409, 2410-2411, 2412-2413, 2414-2415, 2416-2417, 2418-2419, 2420-2421, 2422-2423, 2424-2425, 2426-2427, 2428-2429, 2430-2431, 2432-2433, 2434-2435, 2436-2437, 2438-2439, 2440-2441, 2442-2443, 2444-2445, 2446-2447, 2448-2449, 2450-2451, 2452-2453, 2454-2455, 2456-2457, 2458-2459, 2460-2461, 2462-2463, 2464-2465, 2466-2467, 2468-2469, 2470-2471, 2472-2473, 2474-2475, 2476-2477, 2478-2479, 2480-2481, 2482-2483, 2484-2485, 2486-2487, 2488-2489, 2490-2491, 2492-2493, 2494-2495, 2496-2497, 2498-2499, 2500-2501, 2502-2503, 2504-2505, 2506-2507, 2508-2509, 2510-2511, 2512-2513, 2514-2515, 2516-2517, 2518-2519, 2520-2521, 2522-2523, 2524-2525, 2526-2527, 2528-2529, 2530-2531, 2532-2533, 2534-2535, 2536-2537, 2538-2539, 2540-2541, 2542-2543, 2544-2545, 2546-2547, 2548-2549, 2550-2551, 2552-2553, 2554-2555, 2556-2557, 2558-2559, 2560-2561, 2562-2563, 2564-2565, 2566-2567, 2568-2569, 2570-2571, 2572-2573, 2574-2575, 2576-2577, 2578-2579, 2580-2581, 2582-2583, 2584-2585, 2586-2587, 2588-2589, 2590-2591, 2592-2593, 2594-2595, 2596-2597, 2598-2599, 2600-2601, 2602-2603, 2604-2605, 2606-2607, 2608-2609, 2610-2611, 2612-2613, 2614-2615, 2616-2617, 2618-2619, 2620-2621, 2622-2623, 2624-2625, 2626-2627, 2628-2629, 2630-2631, 2632-2633, 2634-2635, 2636-2637, 2638-2639, 2640-2641, 2642-2643, 2644-2645, 2646-2647, 2648-2649, 2650-2651, 2652-2653, 2654-2655, 2656-2657, 2658-2659, 2660-2661, 2662-2663, 2664-2665, 2666-2667, 2668-2669, 2670-2671, 2672-2673, 2674-2675, 2676-2677, 2678-2679, 2680-2681, 2682-2683, 2684-2685, 2686-2687, 2688-2689, 2690-2691, 2692-2693, 2694-2695, 2696-2697, 2698-2699, 2700-2701, 2702-2703, 2704-2705, 2706-2707, 2708-2709, 2710-2711, 2712-2713, 2714-2715, 2716-2717, 2718-2719, 27

1926R 071 1979  
1926R 071 1979

App. July 1962: 1st report of prof. Jan. of Soc. 14. 1. 1962  
19181 1. 1. 1962

### BOUNDARY LAYERS

Impressed transverse strength increases applied to these three composites. The degree of longitudinal deformation of the fibers and the fiber length are

Copyright © 1977, 1978  
by McGraw-Hill, Inc.

[illegible]

Received 12 October 1983  
Accepted 12 October 1983

1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015  
2016  
2017  
2018  
2019  
2020  
2021  
2022  
2023  
2024  
2025  
2026  
2027  
2028  
2029  
2030  
2031  
2032  
2033  
2034  
2035  
2036  
2037  
2038  
2039  
2040  
2041  
2042  
2043  
2044  
2045  
2046  
2047  
2048  
2049  
2050  
2051  
2052  
2053  
2054  
2055  
2056  
2057  
2058  
2059  
2060  
2061  
2062  
2063  
2064  
2065  
2066  
2067  
2068  
2069  
2070  
2071  
2072  
2073  
2074  
2075  
2076  
2077  
2078  
2079  
2080  
2081  
2082  
2083  
2084  
2085  
2086  
2087  
2088  
2089  
2090  
2091  
2092  
2093  
2094  
2095  
2096  
2097  
2098  
2099  
2100  
2101  
2102  
2103  
2104  
2105  
2106  
2107  
2108  
2109  
2110  
2111  
2112  
2113  
2114  
2115  
2116  
2117  
2118  
2119  
2120  
2121  
2122  
2123  
2124  
2125  
2126  
2127  
2128  
2129  
2130  
2131  
2132  
2133  
2134  
2135  
2136  
2137  
2138  
2139  
2140  
2141  
2142  
2143  
2144  
2145  
2146  
2147  
2148  
2149  
2150  
2151  
2152  
2153  
2154  
2155  
2156  
2157  
2158  
2159  
2160  
2161  
2162  
2163  
2164  
2165  
2166  
2167  
2168  
2169  
2170  
2171  
2172  
2173  
2174  
2175  
2176  
2177  
2178  
2179  
2180  
2181  
2182  
2183  
2184  
2185  
2186  
2187  
2188  
2189  
2190  
2191  
2192  
2193  
2194  
2195  
2196  
2197  
2198  
2199  
2200  
2201  
2202  
2203  
2204  
2205  
2206  
2207  
2208  
2209  
2210  
2211  
2212  
2213  
2214  
2215  
2216  
2217  
2218  
2219  
2220  
2221  
2222  
2223  
2224  
2225  
2226  
2227  
2228  
2229  
2230  
2231  
2232  
2233  
2234  
2235  
2236  
2237  
2238  
2239  
2240  
2241  
2242  
2243  
2244  
2245  
2246  
2247  
2248  
2249  
2250  
2251  
2252  
2253  
2254  
2255  
2256  
2257  
2258  
2259  
2260  
2261  
2262  
2263  
2264  
2265  
2266  
2267  
2268  
2269  
2270  
2271  
2272  
2273  
2274  
2275  
2276  
2277  
2278  
2279  
2280  
2281  
2282  
2283  
2284  
2285  
2286  
2287  
2288  
2289  
2290  
2291  
2292  
2293  
2294  
2295  
2296  
2297  
2298  
2299  
2300  
2301  
2302  
2303  
2304  
2305  
2306  
2307  
2308  
2309  
2310  
2311  
2312  
2313  
2314  
2315  
2316  
2317  
2318  
2319  
2320  
2321  
2322  
2323  
2324  
2325  
2326  
2327  
2328  
2329  
2330  
2331  
2332  
2333  
2334  
2335  
2336  
2337  
2338  
2339  
2340  
2341  
2342  
2343  
2344  
2345  
2346  
2347  
2348  
2349  
2350  
2351  
2352  
2353  
2354  
2355  
2356  
2357  
2358  
2359  
2360  
2361  
2362  
2363  
2364  
2365  
2366  
2367  
2368  
2369  
2370  
2371  
2372  
2373  
2374  
2375  
2376  
2377  
2378  
2379  
2380  
2381  
2382  
2383  
2384  
2385  
2386  
2387  
2388  
2389  
2390  
2391  
2392  
2393  
2394  
2395  
2396  
2397  
2398  
2399  
2400  
2401  
2402  
2403  
2404  
2405  
2406  
2407  
2408  
2409  
2410  
2411  
2412  
2413  
2414  
2415  
2416  
2417  
2418  
2419  
2420  
2421  
2422  
2423  
2424  
2425  
2426  
2427  
2428  
2429  
2430  
2431  
2432  
2433  
2434  
2435  
2436  
2437  
2438  
2439  
2440  
2441  
2442  
2443  
2444  
2445  
2446  
2447  
2448  
2449  
2450  
2451  
2452  
2453  
2454  
2455  
2456  
2457  
2458  
2459  
2460  
2461  
2462  
2463  
2464  
2465  
2466  
2467  
2468  
2469  
2470  
2471  
2472  
2473  
2474  
2475  
2476  
2477  
2478  
2479  
2480  
2481  
2482  
2483  
2484  
2485  
2486  
2487  
2488  
2489  
2490  
2491  
2492  
2493  
2494  
2495  
2496  
2497  
2498  
2499  
2500  
2501  
2502  
2503  
2504  
2505  
2506  
2507  
2508  
2509  
2510  
2511  
2512  
2513  
2514  
2515  
2516  
2517  
2518  
2519  
2520  
2521  
2522  
2523  
2524  
2525  
2526  
2527  
2528  
2529  
2530  
2531  
2532  
2533  
2534  
2535  
2536  
2537  
2538  
2539  
2540  
2541  
2542  
2543  
2544  
2545  
2546  
2547  
2548  
2549  
2550  
2551  
2552  
2553  
2554  
2555  
2556  
2557  
2558  
2559  
2560  
2561  
2562  
2563  
2564  
2565  
2566  
2567  
2568  
2569  
2570  
2571  
2572  
2573  
2574  
2575  
2576  
2577  
2578  
2579  
2580  
2581  
2582  
2583  
2584  
2585  
2586  
2587  
2588  
2589  
2590  
2591  
2592  
2593  
2594  
2595  
2596  
2597  
2598  
2599  
2600  
2601  
2602  
2603  
2604  
2605  
2606  
2607  
2608  
2609  
2610  
2611  
2612  
2613  
2614  
2615  
2616  
2617  
2618  
2619  
2620  
2621  
2622  
2623  
2624  
2625  
2626  
2627  
2628  
2629  
2630  
2631  
2632  
2633  
2634  
2635  
2636  
2637  
2638  
2639  
2640  
2641  
2642  
2643  
2644  
2645  
2646  
2647  
2648  
2649  
2650  
2651  
2652  
2653  
2654  
2655  
2656  
2657  
2658  
2659  
2660  
2661  
2662  
26

1981  
1982  
1983  
1984  
1985

## A-15

## BOUNDARY VALUE PROBLEMS

Numerical analysis of aerodynamic loads on wing and tail surfaces with oscillations in unsteady supersonic and subsonic flow including interference lift  
[AGARD CP 80-21 PT 1] p0007 N71 29-33

Aerodynamic load predicting for control surfaces in unsteady supersonic and subsonic flow p0007 N71 29-33

Numerical analysis of aerodynamic loads and coefficients for tandem and T-tail surfaces harmonically oscillating in subsonic flow p0007 N71 29-33

Wing interference lift-line lattice simulation and application to aerodynamic loads on tandem wings in unsteady flow p0008 N71 29-33

Advances in numerical fluid dynamics p0184 N74 229-14

Boundary conditions for difference approximation of hyperbolic differential equations p0185 N74 229-15

**BRAQO ANGLE**  
HF measurements of ocean wave directional spectra using Bragg backscatter angle p0148 N74 138-67

**BRAIN**  
Myocardial and cerebral function during exposure to carbon monoxide: effects of hypoxia on pilot performance p0065 N74 137-89

**BRAIN CIRCULATION**  
Influence of altitude and drugs on cerebral circulation in smokers and non smokers p0082 N73 211-25  
Partial cerebral hypoxic attacks in pilots as cause of hypoxia incidents p0088 N74 187-86

**BREQUET AIRCRAFT**  
Speed and field length safety factors for approach and landing: mechanics of Brequet aircraft p0028 N71 234-20

**BREQUET 941 AIRCRAFT**  
Flight tests for determining handling qualities and operational characteristics of Brequet 941 STOL aircraft p0054 N73 270-08

**BRIGHTNESS TEMPERATURE**  
Remote satellite microwave sensing of sea surface roughness using water brightness temperature to determine wind fields p0122 N72 160-95

Geometrical optics theory for microwave brightness temperatures through sea surface emissions for remote sensing data interpretation p0124 N72 161-12

**BRISTOL SIDDELEY OLYMPUS 593 ENGINE**  
Efficiency of air-cooling blade design for Olympus 593 gas turbine engine p0257 N71 173-76

**BRITTLE MATERIALS**  
Structural data on brittle nonmetallic materials for use in designing reentry vehicles [AGARD AG 152-21] p0202 N71 200-27

**BROMINE COMPOUNDS**  
Effects of chemical fire extinguishing agents containing bromotrifluoromethane on cardiovascular and nervous systems of dogs, monkeys, and baboons [AGARD R 599] p0077 N73 171-06

**BUBBLES**  
Representations of flow separation bubbles near airfoil leading edge p0027 N71 200-64

**BUFFETING**  
Method for estimating transonic buffet boundary and Reynolds number effects for straight and swept wings p0011 N72 118-57

Transonic wind tunnel determination of Reynolds number effect on jet flap deflection drag divergence pressure distribution and buffet onset p0012 N72 118-61

Transonic wind tunnel model measurements of buffet loads and boundaries at various sweep and aspect ratio wing roots p0016 N72 118-66

Flight tests to determine buffet characteristics of four high performance aircraft during transonic maneuvers p0043 N73 150-17

Analysis of aerodynamic buffeting and related phenomena to include development of models for oscillation rigid body motion p0043 N73 150-18

Prediction of buffet onset for aircraft: recent progress in wind tunnel and flight test data correlation p0021 N74 147-25

**BURSTS**  
Bursts and streamwise momentum deficits in wake region and turbulent boundary layer p0175 N72 202-77

## C

**C BAND**  
Atmospheric measurements on radio attenuation and radar reflectivity: precipitation by microwave frequencies p0115 N71 214-17

**C 5 AIRCRAFT**  
Vortex wake research: inflight investigation of turbulent wake generated by C 5 aircraft p0058 N74 177-33

**C 130 AIRCRAFT**  
Cumulative frequency distributions determined by extreme value analysis used for fatigue analysis and interpretation of log vertical acceleration and gust velocity measured on transport aircraft [AGARD R 579-71] p0030 N71 250-80

**CALIBRATING**  
Advanced procedures for self alignment and calibration of inertial platforms p0230 N73 207-06

**CALORIC REQUIREMENTS**  
Human caloric requirements when working in extreme climatic environments p0070 N71 203-67

## CALORIC STIMULI

Differential diagnosis of the caloric nystagmus: qualitative characteristics of labyrinthine or CNS abnormalities p0108 N74 207-40

Normal limits for the sequential bithermal binocular caloric test p0109 N74 207-46

Thermoelectric stimulation of the labyrinth by Peltier regulated ear canal plug p0109 N74 207-48

## CAMERAS

Characteristics of lenses and ports for underwater imaging systems to compare depth of field and relative aperture for several lens port combinations p0242 N73 336-35

## CANADA

Equipment and facilities for biodynamic research in US and Canada p0095 N71 233-42

Color vision requirements of Canadian Armed Forces including their standard tests p0077 N73 190-70

Information dissemination services of technical information service of National Research Council of Canada p0159 N73 421-11

## CANADIAN AIRCRAFT

The human factor in cyclic aircraft accident patterns: statistical analysis of CF 104 aircraft accident patterns p0107 N74 188-00

## CANTILEVER BEAMS

Laboratory equipment for testing stress corrosion of bolt loaded WOL specimens and monitoring crack growth p0287 N72 219-14

Acoustic emission technique for determining crack growth rate in high strength cantilever steel type specimens p0287 N72 219-17

Pre-cracked cantilever beam and long term beam exposure tests for determining stress corrosion of Al alloys in sea water p0288 N72 219-19

## CARBIDES

Borides, carbides, and nitrides of silicon on oxidation resistant refractory compounds for use in gas turbines and reentry vehicles p0203 N73 236-16

## CARBON DIOXIDE

Physiological responses to interacting stresses of exercise and hyperbaric under acute and chronic exposure to ambient P sub CO2 of 21 mm Hg p0077 N71 203-70

Heat-treated measurements on silicate transmission in carbon dioxide atmosphere p0124 N72 161-08

## CARBON FIBERS

Ultrasonic radiographic eddy current and acoustic emission techniques for nondestructive tests of carbon fiber reinforced polymers and failure mechanisms p0290 N74 249-30

Characteristics of carbon fiber composite materials and application for structures with reduced weight, fatigue reduction and corrosion resistance p0210 N73 274-77

Application of glass composites: all carbon composites and PRD 49 organic fiber material for airframe and spacecraft construction p0211 N73 274-82

Application of glass reinforced and carbon reinforced composite materials for helicopter structures and rotary wings p0211 N73 274-83

Use of reinforced boron and carbon fiber composites in aircraft structures p0211 N73 274-84

Construction of glider aircraft using glass fiber and carbon fiber reinforced plastic composite materials for weight reduction and increased strength p0211 N73 274-86

Application of glass and carbon fiber reinforced structures for gas turbine engine components to operate in high temperature environments p0213 N73 274-95

Performance and fatigue strength of compressor blades fabricated from carbon fiber composites and boron composite wire p0213 N73 274-96

## CARBON MONOXIDE POISONING

Myocardial and cerebral function during exposure to carbon monoxide: effects of hypoxia on pilot performance p0065 N74 137-89

## CARBON STEEL

Random fatigue tests on normalized carbon steel with 0.7 percent carbon p0291 N73 169-02

## CARBON TETRACHLORIDE

Failure of welded joints in Ti-Al-Si-alpha type alloys in CCl4 vapor p0289 N72 219-29

## CARDIOGRAPHY

Value of cardiac mechanograms in evaluating flying personnel p0085 N74 137-91

## CARDIOLOGY

Description of routine cardiology program to determine flight fitness for German Air Force p0097 N72 141-02

## CARDIOVASCULAR SYSTEM

Cardiac and neural effects of UHF radar energy on frogs p0068 N71 203-44

Exercise effects on physical fitness and cardiovascular system of aging pilot p0092 N71 223-13

Cardiac conditions as factor in evaluating flight fitness of Air Force personnel p0096 N72 141-01

## CALICO AIRCRAFT

Development and characteristics of Calico cargo hook system for use on military transport helicopters p0048 N73 210-27

## CASCADE FLOW

Influence of degree of turbulence on aerodynamic coefficients of airfoils p0248 N73 197-98

Analytical approach for loss and deformation behavior of cascades in transonic flow including aerodynamic flow variation p0268 N73 198-97

Singularity method for calculating incompressible flow through cascades with separation p0269 N73 198-92

Effect of axial velocity ratio on aerodynamic coefficients of compressor cascade in viscous flow p0269 N73 198-04

Influence of axial velocity density ratio on compressor cascade performance in compressible flow p0269 N73 198-05

Experiments with cascade secondary flows p0270 N73 198-11

Shock wave boundary layer interaction in compressor cascades p0271 N73 198-16

Boundary layer behavior in supersonic straight and annular blade cascades of fixed and mobile types p0271 N73 198-17

High speed schlieren film of pulsating flow in transonic turbine cascade p0271 N73 198-18

## CASCADES

Effects of boundary layer flow patterns on upright cascade blade performance p0269 N73 198-03

**CASSEGRAIN ANTENNAS**  
Some aspects of near and far angle sketches in double reflector antennas p0147 N73 138-58

## CATALYSIS

Catalytic surface effects on thermocouple combustion gas temperature measurements in jet engines p0257 N71 173-79

## CATAPULTS

Catapult system for launching automobiles and impact studies p0103 N72 191-53

## CAVITIES

Sound field generation by transonic flow over perforated surface liners in wind tunnels p0014 N72 118-78

**CENTRAL ELECTRONIC MANAGEMENT SYSTEM**  
Design of aircraft digital system for automatic flight control p0281 N73 239-00

Human factors in design of aircraft in flight monitoring and automatic landing system for low weather operation p0281 N73 239-01

## CENTRAL NERVOUS SYSTEM

Syngomyelia in central nervous system affecting flying fitness p0083 N73 236-61

**CENTRAL NERVOUS SYSTEM DEPRESSANTS**  
Alcohol reference method for predicting drug modifications of central nervous system activity and pilot performance decrease p0081 N73 211-12

**CENTRAL NERVOUS SYSTEM STIMULANTS**  
Hashish smoking effects on human oxygen consumption during physical stress and safe driving ability p0081 N73 211-15

## CERAMICS

Properties and selective applications of ceramic materials p0205 N71 270-41

## CEREBRUM

Influence of altitude and drugs on cerebral circulation in smokers and non smokers p0082 N73 211-25

Partial cerebral hypoxic attacks in pilots as cause of hypoxia incidents p0088 N74 187-86

## CERTIFICATION

German Air Force experiences with certain criteria for granting a waiver p0087 N74 138-06

## CHANNEL CAPACITY

Frequency correlation measurements on multipath tropospheric scatter propagation p0119 N71 234-65

Impulse response measurements and radio test links for evaluating tropospheric scatter propagation channel capacity p0119 N71 234-66

## CHANNELS (DATA TRANSMISSION)

Feasibility analysis of packet switching networks for remote access computing systems p0158 N72 221-71

Digital computer techniques for filtering and transmission of telecommunication data p0131 N73 101-92

Error probability and bandwidth efficiency in digital transmission channel p0131 N73 101-93

Operational performance and transmission measurements on worldwide Defense Communications System network p0133 N73 102-08

## CHARACTER RECOGNITION

Applying training process to matrix of black and white dots for numeral recognition p0153 N72 111-93

## CHARACTERISTICS

Drag and separation effects of separated flow on aerodynamic drag p0020 N74 147-22

## CHECKOUT

Analysis of stimuli and commands subsystem for checkout and inspection of EUROPA 3 light vehicle p0191 N72 194-90

Application of digital computers for automatic testing and data processing during checkout of satellites p0193 N72 195-03

## CHEMICAL ANALYSIS

Chemical methodology for detection of phosgene and therapeutic drugs in man p0081 N73 211-17

Chromatographic and polarographic methods for determining metabolic levels of hypoxic drugs in blood plasma and urine of man p0081 N73 211-18

A new analytical technique for continuous NO detection in the range from 0.1 to 5000 PPM p0218 N74 142-80

H2 formation in torch flames: A study of the influence of the hydrogen structure p0219 N74 142-87

## CHEMICAL COMPOSITION

Jet fuel specifications for military and civil aircraft p0251 N72 135-39

Measure of impurity constituents in the atmosphere by Cometary O3 p0214 N74 142-88

## CHEMICAL PROPERTIES

Properties of silica as a support for chromatography and chromatographic parameters p0205 N71 270-47

- Discussion of aircraft fuels and lubricants to include production, analysis, testing and fire safety. [AGARD A9 44] p0255 N72 27811
- CHEMICAL REACTIONS**  
Effects of repressivation and crack velocity on stress corrosion cracking in alloys p0286 N72 27907  
One- and two-D core theories for analyzing ductile mixing and burning of coastal streams p0183 N73 17251  
Thermodynamic stability diagrams of high temperature corrosion reactions p0201 N73 23602  
Reaction of ozone with nitrogen oxides at high altitudes p0217 N74 14274
- CHEMICAL TESTS**  
Methods for determining blood alcohol levels in pilots p0082 N73 21124
- CHEMOTHERAPY**  
Drug therapy effects on flying effectiveness and psychomotor fitness of flying personnel p0082 N73 21103  
Chemotherapy for air crews in Great Britain p0080 N73 21105  
Effects of human biodynamics on chemotherapy and drug evaluation p0082 N73 21119  
Suitability of insulin dependent and oral drug dependent diabetics as navigational personnel p0082 N73 21120  
Drug effects on vision of flying personnel p0082 N73 21121  
Flight safety factors in prescribing therapy drugs for flying personnel p0082 N73 21123  
Management of glaucoma in an ageing flying population p0082 N74 13799  
The problem of diabetes mellitus in aviation medicine: control of hypoglycemic reactions in flying personnel p0087 N74 13804
- CHIRP SIGNALS**  
Application of chirp modulation to improve effectiveness of satellite to aircraft communication p0194 N72 19514
- CHLORIDES**  
Sulfur, sodium, and chloride contaminants in gas turbine fuels p0202 N73 23610
- CHROMIUM**  
Addition of chromium to aluminum to improve oxidation resistance of aircraft and combat alloys p0273 N73 23611
- CHROMIUM ALLOYS**  
Effects of toxic dispersions and rare earth elements on oxidation of Cr and Al containing alloys p0202 N73 23608
- CHROMIUM OXIDES**  
Vaporization thermodynamics of Cr2O3 protective scales under transient flow conditions p0202 N73 23607
- CIRCUIT BOARDS**  
Computer aided design of multilayer printed circuit boards p0168 N74 13934  
Optimizing automatic tracking of multilayer boards p0168 N74 13935  
A parallel printed circuit board design system p0168 N74 13936
- CIRCUIT DIAGRAMS**  
SIGMA: An integrated system of computer aided complex circuit designs p0168 N74 13932
- CIRCUIT RELIABILITY**  
Reliability related to computer aided circuit design: A user's view p0165 N74 13909  
Reliability and computer aided design p0165 N74 13910  
Computer aided design for maximum production and/or maximum reliability p0165 N74 13911
- CIRCUITS**  
The teaching of CACA in Denmark p0165 N74 13907  
Computer aided analysis of electronic circuits on a small machine p0167 N74 13925  
IMAG 2: Electronic circuit simulations p0167 N74 13927  
The NASA computer aided design and test system p0168 N74 13931
- CIVIL AVIATION**  
Weather factors in fatal civil regional aircraft accidents p0030 N73 23431  
Drug screening data for civil aviation personnel obtained by metabolites p0080 N73 21104  
Status and trends of civil air traffic control systems and development of automated network for increased flight safety p0233 N73 23696
- CL 84 AIRCRAFT**  
Aerodynamic characteristics of CL 84 (Hawthorn V STOL) aircraft and comparison with handling flight test data documents p0198 N72 32021  
Flight test and evaluation of CL 84 (Hawthorn V STOL) aircraft with applications to specific military roles p0014 N73 27007
- CLEAR AIR TURBULENCE**  
Direct path rate measurements and correlations of clear air turbulence similar to atmospheric boundary layer flow p0178 N72 20292  
Turbulent drag medium and high flight levels: numerical forecasting techniques for clear air turbulence p0057 N74 17273  
Radar experience with low level turbulence performance and forecasting for clear air turbulence detection p0058 N74 17276  
Some new methods of detecting clear air turbulence and its effects on turbulence and aircraft performance and the new way for detecting clear air turbulence p0060 N74 17274
- CLIMATOLOGY**  
Climatology and atmospheric refraction models for worldwide radio wave propagation p0114 N71 21412  
Italian thermal conditions affecting acceleration tolerance and psychomotor performance of flying personnel p0084 N73 23068
- CLIMB/FLIGHT**  
Development of methods for predicting aircraft flight maneuver and climb performance to show effects of excess power and load factor p0053 N73 24045  
Numerical analysis of minimum time climbing procedure and minimum fuel climbing procedure for typical subsonic aircraft p0053 N73 24052
- CLINICAL MEDICINE**  
Clinical causes for permanent grounding of British air force crews p0095 N72 24092  
Clinical causes for permanent grounding of German armed forces flying personnel p0096 N72 24097  
Clinical observation of massive injury causing serum enzyme activity in man after crash accidents p0101 N72 19138  
Naval research in laser caused visual acuity decrement in monkeys and in humans p0076 N72 26056  
Clinical procedures for selecting pilot personnel based on predisposition to motion sickness p0078 N73 21094  
Clinical psychology and psychiatry of the aerospace operational environment: conference p0088 N74 18719  
Fear of flying and its treatment in military pilots p0088 N74 18781  
Results of behavior therapy in flying phobia p0088 N74 18782  
Depression: a review p0088 N74 18784  
Clinical study of loss of aerobically motivation by military flight crews p0088 N74 18785  
Partial cerebral hypoxia attacks in pilots as cause of hypoxia incidents p0098 N74 18786  
Clinical application of hystagmography in diagnosis of human voice system pathology p0108 N74 20733  
Practical problems in clinical hystagmography: a guide lines for selection of equipment: facility for vestibular tests p0108 N74 20734  
A proposed habitation laboratory: Presentation of several results with the PNT p0108 N74 20737  
Interest in hystagmography in flying navigational personnel p0108 N74 20738  
Hystagmography: A useful tool in basic and applied investigations of human neuropsychological systems p0108 N74 20743
- CLOUD COVER**  
Satellite cloud cover observations for determining radio and radar propagation characteristics p0114 N71 21414
- COAXIAL FLOW**  
One and two D core theories for analyzing ducted mixing and burning of coastal streams p0183 N73 17253
- COAXIAL PLASMA ACCELERATORS**  
Analysis of performance of pulsed coaxial guns based on snowplow model allowing for variable initial mass loading distribution p0066 N73 19057
- COBALT ALLOYS**  
Cobalt and nickel based alloy metallurgy for high temperature gas turbine materials p0259 N73 17389  
Addition of chromium to aluminum to improve oxidation resistance of nickel and cobalt alloys p0203 N73 23611  
Comparison of cobalt alloys and nickel alloys relative to hot corrosion resistance p0203 N73 23612
- COBALT 60**  
Development and characteristics of instrument landing system using cobalt 60 gamma rays for runway glide slope and alignment information p0234 N73 23707
- COCHLEA**  
Current aspects of cochlear function applied to flying personnel p0081 N74 13800  
Cochlear and vestibular injuries during diving: inner ear damage and soldiers' deficits p0110 N74 20754
- COCKPIT SIMULATORS**  
Human factors in aircraft simulators p0111 N73 16060  
Human factors in low level cockpit simulation p0171 N73 16065  
Human factors in developing a cockpit simulation program for evaluating aircraft handling aspects [NASA TM X 66583] p0172 N71 16369  
Integrated cockpit research procedures used to identify control and display requirements for advanced aircraft p0223 N72 22625  
Assessment of design: Aircraft cockpit layout and display control system p0224 N72 22629  
Summary of cockpit research in flight simulation p0044 N73 16952
- COCKPITS**  
Problems of cockpit environment p0044 N73 16997  
Case-polymerized light emitting aircraft cockpit environment control system considering man-machine interaction p0281 N73 23905
- CODING**  
Color vision tests: comments for an new personnel of future including coding evaluation [AMRI TR 73 116] p0078 N73 19076
- COGNITION**  
Combined sense and thought effects on human mental and psychomotor performance [AMRI TR 73 115] p0078 N73 19147
- COHERENT LIGHT**  
Principles of holography and various methods for production of holograms p0199 N72 25435  
Comparison of coherent and conventional light sources to show advantages of coherent light for optical experiments p0199 N72 25497  
Application of aerodynamic holography for optical recording and flow visualization in wind tunnels and research facilities p0199 N72 25498  
Calculation of diffraction efficiency and signal to noise ratio for two dimensional and volume diffraction gratings p0199 N72 25501  
Applications of lasers as indirect light source for high speed photography p0200 N72 25504
- COHERENT RADIATION**  
Application of laser beams for measurement of aerodynamic flow fields at supersonic and hypersonic speeds p0200 N72 25503  
Application of incoherent and coherent light sources for underwater illumination and comparison of efficiency for various conditions p0242 N73 23633
- COLLISION AVOIDANCE**  
Proceedings of conference on air traffic control development and procedures [AIAA CP 105] p0232 N73 23689  
Air traffic control facilities operated by US military forces and developments in improved air traffic control systems p0232 N73 23690  
Organization and operation of European air traffic control system and development of improved equipment for identification and reporting p0232 N73 23691  
Status and trends of civil air traffic control systems and development of automated network for increased flight safety p0233 N73 23696  
Numerical analysis of optimal control and sequencing of air traffic control operations in real terminal area p0233 N73 23701  
Development and characteristics of air traffic management system for operation of military aircraft under instrument meteorological conditions p0234 N73 23704  
Development and characteristics of system for separation and control of aircraft to avoid in clear collisions p0235 N73 23712  
Performance tests of air traffic control systems to determine effectiveness in prevention of mid-air collisions p0235 N73 23713  
Analysis of development program for improving US air traffic control procedures for 1980 time period p0235 N73 23718  
Computerized management decision procedures for air operator and pilots on avoidance trajectory conflict p0279 N73 23886
- COLLISIONS**  
External store interference caused by rocket fuel thermal positioning on aircraft wing p0006 N71 19387  
Simulation of frontal collisions and impact sustained by adversaries using safety belts and air bags p0104 N72 19159
- COLLOCATION**  
Box collocation method for calculating aerodynamic loads on tandem delta wings with oscillations in supersonic flow p0008 N71 29337
- COLOR**  
Tradeoffs between luminance and color coding in electronic aircraft displays and experiments involving immediate response tracking tachistoscope and human judgement p0223 N72 22623  
Colors for elements of multicolored aircraft display to insure minimum number of instrument reading errors p0223 N72 22624  
Display principle for 3 D or multicolor solid state 2 D panel displays p0225 N72 22647  
Universal system for assigning colors to terrain [AGARD AG 159] p0187 N72 25346
- COLOR VISION**  
Color vision requirements for flying personnel of various armed forces: conference p0077 N73 19065  
Three color receptors of Young, Helmholtz and opponent color types of information processing p0077 N73 19066  
Color vision requirements for German Air Force personnel p0077 N73 19067  
Color aptitude of dyschromatopic French navigators and pilots p0077 N73 19068  
Color vision testing and selection procedures for flying personnel since World War I p0077 N73 19069  
Color vision requirements of Canadian Armed Forces including their standard tests p0077 N73 19070  
Standardization of tests and classification of color perception among military personnel p0077 N73 19071  
Color vision requirements of Great Britain's Armed Forces p0077 N73 19072  
Comparison of accident rates among color defective and normal personnel p0078 N73 19073  
Color vision tests as predictive indicators of flying task performance p0078 N73 19074  
Main color flying crew light and astrophysics tests and color vision aptitude p0078 N73 19075  
Color vision requirements for a crew personnel of future including coding evaluation [AMRI TR 73 116] p0078 N73 19076
- COMBAT**  
Advantages of laser induced fluorescence in combat air combat simulation p0264 N72 16694

- Application of night vision technology helicopter night scouts p0303 N73 19970  
The reduction of airframe costs with particular reference to combat aircraft p0305 N74 21615

**COMBINED STRESS**

- Combined stress effects on human communication and motion sickness body dynamics p0104 N73 19144  
Combined heat, noise, and vibration effects on aircrew performance [AMRL TR 71 113] p0105 N73 19148  
Combined noise and vibration effects on human mental and psychomotor performance [AMRL TR 71 115] p0105 N72 19147  
Measures to determine psychophysiological reactions of military flight crews to flying stress p0105 N73 19148  
Temperature and noise irradiation effects on human energetic metabolism during vigilance task p0106 N73 19153

**COMBUSTION CHAMBERS**

- Small scale combustion chamber rigs for combustion characteristics determination of aviation fuel p0251 N72 11674  
An experimental research on the behavior of a continuous flow combustion chamber p0220 N74 14296

**COMBUSTION EFFICIENCY**

- Application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers [AGARD AG 168] p0111 N73 18130  
Gas sampling and analysis in combustion phenomena [AGARDGRAPH 168/FRI] p0111 N74 22799

**COMBUSTION PHYSICS**

- Application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers [AGARD AG 168] p0111 N73 18130  
NO formation in fuel-rich flames: A study of the influence of the hydrocarbon structure p0219 N74 14287  
Parameters controlling nitric oxide emissions from gas turbine combustors p0219 N74 14291

**COMBUSTION PRODUCTS**

- Analysis of air pollution caused by aircraft engine emissions in vicinity of airport and comparison with air pollution in urban areas p0271 N73 24788  
Atmospheric Pollution by Aircraft Engines [AGARD CP 125] p0217 N74 14227  
Detailed exhaust emission measurements of three different turbofan engine designs p0217 N74 14270  
Exhaust emission measurements on the GE 164-7 turbo-prop engine p0219 N74 14286  
NO formation in fuel-rich flames: A study of the influence of the hydrocarbon structure p0219 N74 14287  
Soot for nitric oxide in rich kerosene flames at high pressure p0219 N74 14289  
Parameters controlling nitric oxide emissions from gas turbine combustors p0219 N74 14291  
An experimental research on the behavior of a continuous flow combustion chamber p0220 N74 14296  
Sess. 4: Design Opening remarks combustion design policy making and pollution control p0220 N74 14297

- Technical evaluation report on AGARD Technical Meeting on Atmospheric Pollution by Aircraft Engines: recommendation to analyze contribution to air pollution near airports from various sources [AGARD AR 63] p0222 N74 15349

**COMBUSTION TEMPERATURE**

- Catalytic surface effects on thermocouple combustion gas temperature measurements in jet engines p0257 N71 17379  
Soot oxidation kinetics at combustion temperatures p0219 N74 14290

**COMET 4 AIRCRAFT**

- Computerized automated avionics system with electronic display for Comet 4 aircraft navigation p0260 N73 23896

**COMFORT**

- Environmental tests of V-STOL vibration effects on human comfort [NASA TM X 65958] p0068 N71 20356

**COMMAND AND CONTROL**

- Selection of natural language for effective man-machine communication in command and control systems p0151 N72 11178  
Development of user-oriented language for command and control of spacecraft and satellites p0193 N72 19506  
Operating characteristics of integrated aircraft command and control system p0225 N72 22637  
Conceptual analysis of improved communication navigation and identification system for military applications p0235 N73 23719  
Computerized integrated control and information management system with graphic display for manned space flight p0278 N73 23182

**COMMERCIAL AIRCRAFT**

- Aircraft industry survey for analysis of nondestructive inspection methods application to commercial aircraft for 1988 to 1970 p0197 N72 15543

**COMMUNICATION EQUIPMENT**

- Application of a tele-aid satellite for a acquisition and communication functions in air traffic control system p0234 N71 23759  
Development of high bandwidth time division communication system to provide ground based wide area position location system p0234 N73 23717

- Analysis of communications navigation and identification equipment for aircraft and proposed systems for improvement in capability p0236 N73 23720

- Analysis of integrated communications navigation and identification system for aircraft operation and proposal for improved capability p0236 N73 23721

- Proceedings of conference on spread spectrum techniques and application to digital communications systems [AGARD LS 58] p0143 N73 32053

- Principles and operation of spread spectrum communication system with application to satellite communication systems p0143 N73 32056

- Applications of spread spectrum communications techniques to avionics systems p0143 N73 32058

**COMMUNICATION THEORY**

- Development of user-oriented language for command and control of spacecraft and satellites p0193 N72 19506

- Proceedings of conference on spread spectrum techniques and application to digital communications systems [AGARD LS 58] p0143 N73 32053

- Fundamental concepts of communication theory to include transmission of continuous signals and use of discrete time signals p0143 N73 32054

- Characteristics of digital communication systems and processing of bandpass digital signals using spread spectrum techniques for data transmission p0143 N73 32055

- Principles and operation of spread spectrum communication system with application to satellite communication systems p0143 N73 32056

- Performance of spread spectrum communication systems to include effects of various forms of channel noise and synchronization aspects of system p0143 N73 32057

- Applications of spread spectrum communication techniques to avionics systems p0143 N73 32058

**COMPENSATORY TRACKING**

- Adaptive tracking task for evaluating drug after effects on human flight performance p0080 N73 21109

**COMPETITION**

- Sports medicine: parameters necessary for maintaining competitive form p0081 N71 21111

**COMPLEX SYSTEMS**

- Automated sizing of large structures by mixed optimization methods p0297 N74 15611

**COMPONENT RELIABILITY**

- Methods of testing rotating components of turbomachines compared with tests on complete turbomachines [AGARD AG 167] p0271 N73 26800

**COMPOSITE MATERIALS**

- Properties and selective applications of high strength steel, aluminum and titanium alloys, polymeric materials, ceramic materials, and composite materials in aerospace engineering [AGARD LS 51 71] p0205 N71 27038

- Mechanical properties of fiber reinforced materials p0206 N71 27043

- Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials conference [AGARD CP 63 71] p0206 N72 12492

- Mechanical properties of silica fiber reinforced epoxy composite materials p0207 N72 12493

- Ultrasonic measurements on silica epoxy and silica phenolic sheets in liquid filled tank p0207 N72 12494

- Extensometric measurements of elastic modulus on resin fiber composite materials p0207 N72 12495

- Linear and nonlinear stress characteristics of epoxy silica composite materials p0207 N72 12496

- Theoretical and experimental determination of elastic constants in silica epoxy composite materials p0207 N72 12497

- Error sources in elastic stress measurements on fiber reinforced composite materials p0207 N72 12498

- Temperature and fiber orientation effects on mechanical behavior of silica-epoxy composite materials p0207 N72 12499

- Axial tension tests for stress-strain response of matrix and reinforcing fibers in glass epoxy resin composites p0207 N72 12500

- Manufacturing of aluminum beryllium composites by hot pressing p0208 N72 12503

- Photoelastic measurement of monolithic wetting by reinforcing resins of composite materials p0208 N72 12506

- Methods for fabricating and predicting viscoelastic constants of composite materials p0209 N72 12508

- Conference on Structural Applications of Advanced Composites [AGARD LS 55] p0209 N72 29589

- Relationship between effective properties of fiber composite materials and mechanical and geometric properties of their constituents p0209 N72 29590

- Fundamental principles for selecting reinforcements for composite materials p0209 N72 29591

- Composites in structural design process p0209 N72 29592

- Techniques for measuring plastic, viscoelastic, ultimate and high temperature mechanical properties of fiber reinforced composites p0209 N72 29593

- Methods for optimum design of composite structures p0209 N72 29594

- Comparing characteristics of advanced composites with those of conventional and metal materials p0210 N72 29595

- Primary and secondary structural applications of advanced composites p0210 N72 29596

- Effects of substrates on stability of superconductor and electrical properties of superconductors for various conditions p0063 N73 19031

- Development and application of composite materials for vertical takeoff aircraft airframes and effect on improved aircraft performance p0046 N73 21023

- Proceedings of conference on application of composite materials in construction of aerospace vehicles and propulsion systems [AGARD CP 112] p0210 N73 27474

- Physical and mechanical properties of high strength high modulus reinforcing fibers and organic resin composite materials p0210 N73 27475

- Analysis of properties of fiber reinforced materials with plastic and metallic matrix composition and application to gas turbine engines p0210 N73 27476

- Characteristics of carbon fiber composite materials and application for structures with reduced weight, fatigue reduction and corrosion resistance p0210 N73 27477

- Production of fibrous metal composites by rolling of powder with strong reinforcing wires and application to aerospace vehicle structures p0210 N73 27478

- Design of laminar composite materials for application to construction of airframes and spacecraft structures p0210 N73 27479

- Application of boron/epoxy composite materials for airframe construction with specific development of F-111 stabilizer p0211 N73 27480

- Application of composite materials for structural purposes to show limitations and failure characteristics p0211 N73 27481

- Application of glass composites, all carbon composites and PRD 49 organic fiber material for airframe and spacecraft construction p0211 N73 27482

- Application of glass reinforced and carbon reinforced composite materials for helicopter structures and rotary wings p0211 N73 27483

- Use of reinforced boron and carbon fiber composites in aircraft structures p0211 N73 27484

- Application of composite materials to reinforce metallic structures for low cost improvement in structural stability of airframes p0211 N73 27485

- Application of composite materials and sandwich structures to reduce vulnerability of aircraft structures to projectile impact p0212 N73 27487

- Response of general laminated plates to applied loads with coupling between bending and extensional modes of deformation p0212 N73 27488

- Design and manufacturing of composite materials with organic matrices for use in aerospace vehicle structures subjected to high temperatures p0212 N73 27489

- Application of reinforced composite materials for construction of aeronautical gas turbine engine p0212 N73 27490

- Development of fiber reinforced composite materials for application in air breathing engines, aeronautical vehicles and spacecraft components p0212 N73 27491

- Production of lamellar and fibrous composite materials from directional solidification of eutectic alloys and application to gas turbine blades and vanes p0212 N73 27492

- Application of directly solidified eutectics for testing and construction of gas turbine engines p0212 N73 27493

- Application of glass and carbon fiber reinforced structures for gas turbine engine components to operate in high temperature environments p0213 N72 27495

- Performance and fatigue strength of compressor blades fabricated from carbon fiber composites and boron composite wires p0213 N73 27496

- Application of boron aluminum composite materials for construction of turbine blades with low notch sensitivity in high cycle fatigue p0213 N73 27497

- Design fabrication and test of boron/polyimide reinforced titanium fan disks to operate at high temperatures p0213 N73 27498

- Performance and endurance of compressor disks bound with boron composite wires p0213 N73 27499

- Failure analysis of fiber reinforced composite rocket engine case using distention energy and maximum strain theories of failure p0213 N73 27500

- Analysis of programs for acoustic testing of composite material components and development of theory for predicting natural frequencies, mode shapes and stresses in composite panels p0293 N73 29918

- Direction of research activities on matrix composites [AGARD R 699] p0304 N74 17664

**COMPOSITE STRUCTURES**

- Non-destructive test to failure, inspection and quality control of composite structures and materials reinforcement [AGARD R 590] p0293 N72 24934

- Non-destructive tests applied to quality control of a 4 frames made of boron composites p0290 N72 24936

- Response of general laminated plates to applied loads with coupling between bending and extensional modes of deformation p0212 N73 27488

**COMPRESSIBILITY**

- Existence of velocity potential for viscous fluid flow and use of compressibility in turbulent subsonic systems in flow p0176 N72 20282

**COMPRESSIBILITY EFFECTS**

Prediction of buffet onset for aircraft: recent progress in wind tunnel and flight test data correlation p0021 N74 14725

**COMPRESSIBLE BOUNDARY LAYER**

Effects of adverse pressure gradient on compressible turbulent boundary layer flow p0179 N72 20299

**COMPRESSIBLE FLOW**

Starting conditions of mixed compression axisymmetric hypersonic jet p0167 N72 16715

Model for compressible turbulent boundary layer applicable to flows with pressure gradient and surface mass transfer p0176 N72 20783

Influence of axial velocity field ratio on compressor cascade performance in compressible flow p0269 N73 19805

Effects of aerodynamic drag on rotary wing performance and methods for reducing influence of stall and compressibility parameters p0117 N73 22954

**COMPRESSOR BLADES**

Interference effect between oscillating and distorted inlet flow on compressor stall p0003 N71 19370

Effects of boundary layer flow pattern on upright cascade blade performance p0269 N73 19803

Effect of axial velocity ratio on aerodynamic efficiency of compressor cascade in viscous flow p0263 N73 19804

Performance and fatigue strength of compressor blades fabricated from carbon fiber composites and boron composite resins p0213 N73 21496

**COMPRESSORS**

Velocity distribution measurement of axial compressor inlet for compressor matching p0267 N72 16714

Performance and endurance of compressor gas bound with boron composite wires p0213 N73 21499

Hydraulic compressor wind tunnel p0174 N74 16992

**COMPUTER DESIGN**

Using cellular logic for pattern recognition p0154 N72 11198

Hardware organization and system design of guidance and control computers p0155 N72 12124

Aerospace computer input/output techniques for consideration in design phase of interfacing equipment p0156 N72 12129

Research activities of electronic laboratory in development of central aviation systems to include applications for space missions and commercial aviation p0227 N73 20686

Systems design for spaceborne computer engineering module p0280 N73 23894

**COMPUTER GRAPHICS**

Integrated preprocessing system for the extraction of binary pictures p0153 N72 11192

Applying thinning process to marks of black and white dots for numeral recognition p0153 N72 11193

Signal analysis and computer graphics for signal classification systems p0154 N72 11203

Interactive graphics techniques for handling pictorial data and applications to pattern recognition and artificial intelligence p0154 N72 11203

Detecting boundaries of objects in gray pictures p0155 N72 11205

Problem solving using man-machine interaction for pattern recognition by dynamic pictorial information p0155 N72 11205

Hybrid character generator combining stroke writing and linguistic structure for anthropomorphic alteration of integrated displays p0224 N72 22678

An evolving operational computer aided design system using high level graphical language p0167 N74 13929

A computer controllable character terminal p0160 N74 16936

A research workers view on the future of automatic reading machines p0161 N74 16938

**COMPUTER PROGRAMMING**

Unconstrained minimization formulations of constrained problem and penalty functions p0264 N71 20134

Automatic medical diagnosis using nonparametric sequential pattern classification procedures p0152 N72 11184

Programming characteristics of future guidance and control computers p0156 N72 21216

Data word length considerations for aerospace computer implementation to obtain required precision levels p0156 N72 21217

Analog non computer program for analysis of extended electrocardiographic monitoring p0074 N72 25053

**COMPUTER PROGRAMS**

Computer program for determining low speed interference effects of flow fields about arbitrary bodies by superposition p0005 N71 19377

Computerized prediction of flow field interference forces and moments on aircraft stores at subsonic speeds p0006 N71 19385

Computer programs for evaluating subsonic flow over wing tail wings with folded tips, T-tails and cruciform tail surfaces p0009 N71 29341

Computer programs for calculating aerodynamic efficiency of wing horizontal tail and fin horizontal tail operation in subsonic flow p0009 N71 29342

Question answering system DELFI for automatic generation of programs to express semantic content of English like sentences in procedural intermediate language p0151 N72 11177

Generation and checkout of computer programs for real time control of aerospace vehicles p0155 N72 21215

Analysis of methods for predicting aircraft performance and recommendations for computer programs to provide accurate prediction capabilities p0040 N72 32036

Systems design for spaceborne computer engineering module p0280 N73 23894

Computer programs for analyzing optical properties of sea water p0243 N73 33638

Current loads technology for helicopter rotors based on rotor loads computer program for determining fatigue design loads p0056 N74 10910

A computer program for analyzing waveguide structures p0166 N74 13919

Microwave circuit analysis by digital computer p0166 N74 13922

A numerical model of TEC over the Mediterranean area p0187 N74 14086

**COMPUTER STORAGE DEVICES**

Digital filtering procedures for line images with plan position indicators p0155 N72 11194

Aerospace computer memory technology and application of particular techniques to various system requirements p0156 N72 21219

**COMPUTER SYSTEMS DESIGN**

Serial digital data bus for integrated avionics system interface p0157 N73 23902

**COMPUTER SYSTEMS PROGRAMS**

Extensive computer language for real time simulation of process control in large systems p0279 N73 23892

**COMPUTER TECHNIQUES**

Computer aided input of graphic information on chemical structures by keyboarding under visual control of display device p0157 N72 22170

Design and operation of communications system utilizing computer input/output communications for application to commercial organization p0156 N72 22173

Automatic analysis of ECG at rest during and after exercise with two computer systems p0073 N72 25052

Online computer technique for evaluating reconnaissance area image compression algorithms p0131 N73 10191

Real time computerized message switching and data transmission systems for military communications network p0133 N73 10206

Automated technical aid for system for military communications facility p0133 N73 10207

Development of automated traffic control system using computer techniques to provide flight safety for increased air traffic p0232 N73 23632

Analysis of interface between controller and computer in automated air traffic control system p0235 N73 23715

Electronic computer processing of data stored in data banks p0153 N73 24212

An optimization technique for computer simulation of parameter identification in computer method p0156 N74 13915

Linear transition model of RF network analysis: Adaptation between measurement and analysis by computer p0166 N74 13916

Trends towards standardized software and hardware for test systems based on process computer with interface unit and input/output peripherals p0236 N74 14351

New developments in storage retrieval and dissemination of aerospace information p0159 N74 16925

A computer produced keyword indexing system for technical reports in the library of the Aircraft Research Association limited p0159 N74 16926

Aerospace information services: Progress with the ESRO ELDO computerized information network p0160 N74 16928

The role of CSIB in information research and development p0160 N74 16929

Current ASTIB research on mechanism p0160 N74 16930

Microlith and reprographic systems: A state of the art review p0160 N74 16932

Remote transmission and automatic retrieval techniques p0160 N74 16933

Retrieval of microfilm: Part two annex p0160 N74 16934

A microfilm system for small users p0160 N74 16935

Abstracts on microfiche for on-line retrieval p0161 N74 16937

A change in aerodynamics on-line computer technique for eye data processing p0110 N74 20751

Research work and costs: the role of data processing in aircraft production p0305 N74 21617

**COMPUTERIZED DESIGN**

Computerized optimization of thermal resistant gas turbine blades p0260 N71 17400

Computerized prediction of aerodynamic lifting characteristics for wing horizontal tail and cruciform wing configurations p0002 N71 19361

Mathematical programming techniques applied to aerospace structural design algorithm: recent applications and literature review p0281 N71 20128

Basic concepts of mathematical programming applied to structural design of aerospace vehicles p0283 N71 20129

Assessment of structural design philosophy controlling computerized structural analysis with mathematical programming p0283 N71 20130

Mathematical programming applications to structural design optimization: literature review p0283 N71 20132

Computer programs for optimum least weight design of complex elastic aerospace structures p0284 N71 20136

Computerized design of stiffened cylindrical shells and ablating composite heat shields p0284 N71 20137

Computer and optimization techniques in aircraft design p0285 N71 20140

Computerized design of lighter aircraft cockpit electronic control system considering man-machine interaction p0281 N73 23905

Parameter and optimization techniques for aircraft design synthesis to show principal parameters of data flow in component development p0053 N73 24049

Computer aided design for electronic circuits: a review p0155 N74 13906

The teaching of CADA in Denmark p0165 N74 13907

Economics of CAD: A new approach p0165 N74 13908

Reliability related to computer aided circuit design: A user's view p0165 N74 13909

Reliability and computer aided design p0165 N74 13910

Computer aided design for parametric optimization: a preliminary study p0165 N74 13911

Computer aided design concepts p0165 N74 13912

Transistor equivalent method for three dimensional circuits of operational amplifiers and bipolar transistors p0165 N74 13914

State of art and future trends of computer aided design of microwave integrated circuits p0156 N74 13918

Computer optimization of microwave integrated circuit design p0156 N74 13920

SAP (Simulation Analysis Program): A program for the analysis and design of microwave circuits p0156 N74 13921

Synthesis of passive filters with infinite attenuation points realized with weak noise components applied to high degree Chebyshev filters p0167 N74 13923

Computer design of equalizer equalization p0167 N74 13924

Computer aided analysis of electronic circuits on a small scale p0167 N74 13925

Structure and application of computer program ICAS: Integrated circuit AC analysis p0167 N74 13926

Computer aided design analysis of modern large scale circuits and subsystems p0167 N74 13928

An evolving operational computer aided design system using high level graphical language p0167 N74 13929

Specification and design languages for logic synthesis p0158 N74 13930

The NASA computer aided design and test system p0168 N74 13931

SIGMA: An integrated system of computer aided complex circuit designs p0168 N74 13932

A computer aided design system for logic and integrated digital networks p0168 N74 13933

Computer aided design of modular printed circuit boards p0168 N74 13934

Optimizing automatic tracking of multiple targets p0168 N74 13935

A parallel printed circuit board design system p0168 N74 13936

Computer aided placement and routing of high density chip interconnected systems p0168 N74 13937

Figural recognition of information: principles and computer design for automatic systems p0168 N74 13938

Computerized simulation of propulsive scatter channel distortion using Monte Carlo methods p0119 N71 23467

Mission requirements for air to air missile and digital computer program to synthesize requirements into preliminary design p0226 N72 21682

Analysis of digital and analog computer techniques for simulation of missile guidance and control and application of hybrid simulation procedures p0226 N72 21687

Computerized simulation of gravity wave perturbed traveling ionospheric disturbances using ray paths p0139 N73 14163

Computerized simulation of ionospheric altitude control system for satellite with flexible booms p0279 N73 23890

Simulation model for optimum spaceborne computer system design controlling satellite booms systems p0279 N73 23891

The use of the Transputer simulation program SILEX for statistical ordering of bipolar transistors p0165 N74 13913

SPICE 2: Electronic circuit simulator p0167 N74 13922

CONCORDE AIRCRAFT

Human factors in Concorde cockpit simulation p0171 N71 16065

Feasibility study of four state computer engine engine combustion of Concorde power plant p0265 N72 16704

# CONFERENCES

Concorde power plant development emphasizing flight test problems p0265 N72 16705  
Mathematical models for determining flight performance of Concorde aircraft p0034 N72 20978  
Methods and instruments for determining performance of Concorde aircraft p0035 N72 20982  
Passive dosimetric interpretation of chemic radiation dose rate onboard French prototype of Concorde's O1 supersonic transport aircraft p0075 N72 26052  
Processing of Concorde digitally recorded data p0195 N73 10453  
Simulation of flight in Concorde for improving characteristics of flight control system p0048 N73 17013  
Reliability design of manned supersonic aircraft considering safety hazards p0278 N73 23883  
Measure of minor constituents in the stratosphere by Concorde 001 p0219 N74 14288

## CONFERENCES

Human factors in aircraft simulation p0171 N71 16060  
[AGARD CP 79 70] p0171 N71 16060  
Advanced cooling systems and heat resistant materials for turbine blades of high temperature aeronautical gas turbine engines p0257 N71 17372  
[AGARD CP 73 71] p0257 N71 17372  
Critical review and round table discussion data for colloquium on reactions between gases and solids p0261 N71 19177  
[AGARD AR 32 71] p0261 N71 19177  
Aerodynamic interference characteristics of a flame propulsion system of transport and military aircraft p0001 N71 19353  
[AGARD CP 71 71] p0001 N71 19353  
Aerodynamics and applications of lift augmentation devices AGARD lecture series p0025 N71 20051  
[AGARD LS 43 71] p0025 N71 20051  
North Atlantic Treaty Organization conference on adaptation and acclimatization in aerospace medicine p0067 N71 20351  
[AGARD CP 82 71] p0067 N71 20351  
Tropospheric characteristics and their effects on electromagnetic wave propagation and radio signal transmission p0114 N71 21409  
[AGARD CP 70 71 PT 1] p0114 N71 21409  
Physical fitness of living personnel and aging effects on flight crew performance p0091 N71 22301  
[AGARD CP 81 71] p0091 N71 22301  
Conference on high temperature turbines detailing effect of film cooling on blade profile loss p0261 N71 22699  
[NASA (M X 61) 72] p0261 N71 22699  
Tropospheric scatter propagation and prediction of radio transmission characteristics p0117 N71 23451  
[AGARD CP 70 71] p0117 N71 23451  
Symposium on unsteady aerodynamic forces loads and configurations for aerelastic analysis of interfering surfaces p0008 N71 29338  
[AGARD CP 80 71 PT 2] p0008 N71 29338  
Conference papers on aerelasticity with emphasis on pattern recognition and man machine interface problem solving p0151 N72 11174  
[AGARD CP 94 71] p0151 N72 11174  
Aircraft fuels lubricants and fire safety conferences p0251 N72 11668  
[AGARD CP 84 71] p0251 N72 11668  
Conference on theoretical methods and wind tunnel facilities for transonic aerodynamic testing of aircraft at high Reynolds numbers p0011 N72 11854  
[AGARD CP 83 71] p0011 N72 11854  
Helicopter guidance and control systems conference p0030 N72 11915  
[AGARD CP 86 71] p0030 N72 11915  
Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials conference p0206 N72 12492  
[AGARD CP 63 71] p0206 N72 12492  
Satellite attitude control systems NATO conference p0277 N72 12867  
[AGARD LS 45 71] p0277 N72 12867  
General and specific medical causes for grounding flying personnel conferences p0095 N72 14093  
[AGARD CP 89 71] p0095 N72 14093  
Conference on propagation ranges of microwave infrared and photographic remote sensing systems for pollution detection and sea state roughness measurements p0121 N72 16085  
[AGARD CP 90 71] p0121 N72 16085  
Engine aircraft interference thrust inlet nozzles and propulsion systems conference p0263 N72 16685  
[AGARD CP 91 71] p0263 N72 16685  
Design testing and use of heat exchangers in industrial and aerospace vehicles conference p0299 N72 18546  
[AGARD LS 57] p0299 N72 18546  
Linear acceleration of impact type causing human injuries conferences p0098 N72 19119  
[AGARD CP 88 71] p0098 N72 19119  
Proceedings of conference on avionics in spacecraft covering component technology instrumentation satellite subsystems and satellite systems p0190 N72 19483  
[AGARD CP 87 71] p0190 N72 19483  
Turbulent boundary layers jets and wakes conferences p0175 N72 20273  
[AGARD CP 93] p0175 N72 20273  
Proceedings of conference on aircraft flight test procedures data acquisition data processing and correlation with wind tunnel test results p0034 N72 20976  
[AGARD CP 85] p0034 N72 20976  
Characteristics and effects of Arctic ionosphere on radio and radar propagation conference p0126 N72 21121  
[AGARD CP 97] p0126 N72 21121  
Standardization of test procedures for determining stress corrosion cracking in high strength alloys and steels under various environments conference p0285 N72 21900  
[AGARD CP 98] p0285 N72 21900

Video storage and transmission systems for documentation and dissemination of information conferences p0157 N72 22168  
[AGARD CP 92] p0157 N72 22168  
Guidance and control display design for aircraft and spacecraft conference p0223 N72 22621  
[AGARD CP 98] p0223 N72 22621  
Nondestructive test for failure inspection and quality control of composite structures and materials conference p0290 N72 24934  
[AGARD R 593] p0290 N72 24934  
Proceedings of conference on medical aspects of spatial disorientation and effects on safe aircraft operation p0071 N72 25031  
[AGARD CP 95 PT 1] p0071 N72 25031  
Arrummedal requirements and examination techniques for aircrews conference p0073 N72 25048  
[AGARD CP 95 PT 2] p0073 N72 25048  
Proceedings of conference on applications of laser technology for aerodynamic measurements p0199 N72 25493  
[AGARD LS 49] p0199 N72 25493  
Conferences on biophysical approaches to solving problems of ionizing and nonionizing radiation effects during high altitude flight manned space flight and ground based equipment p0075 N72 26045  
[AGARD CP 95 PT 3] p0075 N72 26045  
Numerical analysis of one two and three dimensional fluid flow conferences p0181 N72 27293  
[AGARD LS 48] p0181 N72 27293  
Conference on Structural Applications of Advanced Composites p0209 N72 29589  
[AGARD LS 55] p0209 N72 29589  
Proceedings of conference on handling qualities and performance criteria for conventional and V-STOL aircraft p0038 N72 32017  
[AGARD CP 106] p0038 N72 32017  
Conference on expanded aerospace telecommunication system requirements and digital data transmission methods p0130 N73 10187  
[AGARD CP 103] p0130 N73 10187  
Proceedings of conference to analyze static and dynamic loads exerted on helicopter rotary wings and application to improved helicopter design p0016 N73 14000  
[AGARD R 595] p0016 N73 14000  
Conference on acoustic gravity wave effects in atmospheric transmission of radio communication signals p0134 N73 14131  
[AGARD CP 115] p0134 N73 14131  
Proceedings of conference on fluid dynamics of aircraft stall to include stall and post stall aerodynamic characteristics of various military aircraft p0041 N73 14998  
[AGARD CP 102] p0041 N73 14998  
Random load fatigue of aircraft structures conferences p0291 N73 16896  
[AGARD CP 118] p0291 N73 16896  
Summaries of papers presented to conference concerning aircraft stability and control p0043 N73 16989  
[AGARD CP 119] p0043 N73 16989  
Summary of conference on flight simulation p0044 N73 16992  
[AGARD CP 116] p0044 N73 16992  
Conference on flight handling qualities and requirements p0044 N73 16993  
[AGARD CP 117] p0044 N73 16993  
Evaluation of conference to investigate current and future development in aircraft electrical and auxiliary power systems p0063 N73 18081  
[AGARD AR 53] p0063 N73 18081  
Summary of conference on stress concepts of testing methods p0292 N73 18931  
[AGARD AR 52] p0292 N73 18931  
Proceedings of conference on application of superconductivity techniques to auxiliary power systems for aircraft and missiles p0063 N73 19030  
[AGARD CP 104] p0063 N73 19030  
Color vision requirements for flying personnel of various armed forces conferences p0077 N73 19065  
[AGARD CP 95] p0077 N73 19065  
Conference on operational flight stress effects on human performance and performance p0104 N73 19143  
[AGARD CP 101] p0104 N73 19143  
Proceedings of conference on neural navigation components and systems with emphasis on concepts and techniques involving cost and performance tradeoffs p0277 N73 20684  
[AGARD CP 116] p0277 N73 20684  
Proceedings of conference on rotary wing aircraft development to include operational experience flight tests and evaluation of structural concepts p0046 N73 21008  
[AGARD CP 121] p0046 N73 21008  
Proceedings of conference on fluid dynamics of rotary wings and aerodynamic characteristics of rotary wing system p0049 N73 21031  
[AGARD CP 111] p0049 N73 21031  
Predictability of motion sickness in pilot selection conferences p0078 N73 21092  
[AGARD CP 109] p0078 N73 21092  
Conference on detection evaluation and identification of drugs and alcohol in flying personnel and effects on flight fitness p0079 N73 21102  
[AGARD CP 108] p0079 N73 21102  
Annual AGARD meeting in Brussels Belgium p0104 N73 21881  
[AGARD CP 110] p0104 N73 21881  
Proceedings of conference on rotary wings to investigate both static and dynamic characteristics in hover and high advance ratio and aerodynamic noise properties p0052 N73 21931  
[AGARD AR 61] p0052 N73 21931  
Aerospace medicine research including human tolerance to various stress factors conferences p0083 N73 23057  
[AGARD CP 110] p0083 N73 23057

Conference on high temperature corrosion of alloys for aerospace applications p0201 N73 23597  
[AGARD CP 120] p0201 N73 23597  
Conference on atmospheric attenuation and rainfall effects on ultrahigh frequency telecommunication systems p0140 N73 26121  
[AGARD CP 127] p0140 N73 26121  
Proceedings of conference on military applications of V-STOL aircraft to include current and proposed research projects to meet military requirements p0054 N73 27000  
[AGARD CP 126 VOL 1] p0054 N73 27000  
Proceedings of conference on application of composite materials in construction of aerospace vehicles and propulsion systems p0210 N73 27474  
[AGARD CP 112] p0210 N73 27474  
Summaries of papers presented to AGARD conference on random load fatigue p0292 N73 28884  
[AGARD AR 54] p0292 N73 28884  
Proceedings of conference on acoustic fatigue to show effects of aerodynamic loads response of structures structural design and fatigue test methods p0292 N73 29905  
[AGARD CP 113] p0292 N73 29905  
Proceedings of symposium to determine requirements and configurations of emergency ejection systems for helicopter crews p0055 N73 31954  
[AGARD AR 62] p0055 N73 31954  
Proceedings of conference on spread spectrum techniques and application to digital communication systems p0143 N73 32053  
[AGARD LS 58] p0143 N73 32053  
Proceedings of conference on electromagnetic and optical properties of sea water for application to surveillance mapping communications and visibility p0241 N73 33619  
[AGARD LS 61] p0241 N73 33619  
Technical evaluation report on Fluid Dynamics Panel Specialists Meeting on Aerodynamic Drag p0018 N74 16935  
[AGARD AR 58] p0018 N74 16935  
Specialists Meeting on Helicopter rotor Prediction Methods p0055 N74 10998  
[AGARD CP 122] p0055 N74 10998  
Pathophysiological conditions compatible with flying p0084 N74 13784  
[AGARD CP 129] p0084 N74 13784  
Propagation effects of frequency sharing p0145 N74 13846  
[AGARD CP 127] p0145 N74 13846  
Computer aided design for electronic circuits conference p0165 N74 13906  
[AGARD CP 130] p0165 N74 13906  
Atmospheric Pollution by Aircraft Engines p0217 N74 14271  
[AGARD CP 125] p0217 N74 14271  
Testing philosophy and methods of guidance and control systems and subsystems applied to navigation systems for aircraft spacecraft and missiles p0236 N74 14345  
[AGARD LS 60] p0236 N74 14345  
Aerodynamic Drag p0018 N74 14769  
[AGARD CP 124] p0018 N74 14769  
Second Symposium on Structural Optimization p0292 N74 15596  
[AGARD CP 123] p0292 N74 15596  
New developments in storage retrieval and dissemination of aerospace information p0159 N74 16925  
[AGARD CP 136] p0159 N74 16925  
Flight in turbulence proceedings of conference on atmospheric turbulence and effects on aircraft operation p0057 N74 17720  
[AGARD CP 140] p0057 N74 17720  
Clinical psychology and psychiatry of the aerospace operational environment conference p0088 N74 18779  
[AGARD CP 133] p0088 N74 18779  
Behavioral aspects of aircraft accidents conference on human factors research projects for reduction of pilot error aircraft accidents p0106 N74 18797  
[AGARD CP 132] p0106 N74 18797  
Design against fatigue conference on the fatigue life assessment of tactical aircraft p0060 N74 19052  
[AGARD CP 141] p0060 N74 19052  
The use of cinematography in aviation medicine aerospace medicine meeting on hypoxia p0107 N74 20732  
[AGARD CP 128] p0107 N74 20732  
AGARD Annual Meeting 1973 conference on research and development in Greece a discussion of science and technology to meet military requirements at reduced costs p0304 N74 21610  
[AGARD CP 142] p0304 N74 21610  
Metallurgical aspects of fatigue and fracture toughness conference on effects of microstructure on mechanical properties of a frame materials p0204 N74 23108  
[AGARD R 610] p0204 N74 23108  
The 1971 AGARD Annual Meeting p0306 N74 23494  
[AGARD CP 143] p0306 N74 23494  
International conference management p0305 N74 23495  
[AGARD CP 144] p0305 N74 23495  
**CONNECTIVE TISSUE**  
Structural and mechanical characteristics of human connective tissue p0101 N72 19140  
[AGARD CP 145] p0101 N72 19140  
**CONSERVATION EQUATIONS**  
Conservation equations for a flying supersonic and many low-regime of supersonic jets p0183 N73 11249  
[AGARD CP 146] p0183 N73 11249  
**CONSTRAINTS**  
Unconstrained minimization of simulations of structural problems and penalty functions p0284 N71 20134  
[AGARD CP 147] p0284 N71 20134  
Restraints for passengers in automobiles p0098 N72 19122  
[AGARD CP 148] p0098 N72 19122  
Linear and angular acceleration from motion human acceleration in dynamic airplane entry and exit systems and mathematical models of aircraft crash loads p0103 N72 19155  
[AGARD CP 149] p0103 N72 19155  
Protective Aspects of Passive Restraints for Vehicle p0103 N72 19156  
[AGARD CP 150] p0103 N72 19156

# SUBJECT INDEX

## SUBJECT INDEX

Simulation of frontal collisions and injuries sustained by cadavers using safety belts and air bags p0104 N72 19159

Application of discriminate function technique to random search in nonlinear constrained structural optimization problems p0296 N74 15603

### CONSTRUCTION MATERIALS

Dilatometric thermal expansion measurements on high temperature structural materials [AGARD R 31 71] p0299 N71 25358

Properties and selective applications of high strength steels p0205 N71 27040

Properties and selective applications of thermosetting and thermoplastic polymers p0205 N71 27042

Effects of environmental stresses on materials used in constructing glide recovery vehicles p0201 N73 23601

Refractory metal alloys with protective coatings for use in structural components of turbine engines p0203 N73 23614

Analysis of heat transfer properties and thermophysical properties of materials used for aircraft and spacecraft construction [AGARD R 606] p0300 N73 25968

Applications of composite materials for structural purposes to show limitations and failure characteristics p0211 N73 27481

The metallurgical aspects of fatigue and fracture toughness tests of microstructure in mechanical properties of airframes and construction materials p0204 N74 23109

Influence of microstructure on the growth of fatigue cracks: analysis of processes which govern crack propagation rate p0204 N74 23112

### CONTAMINANTS

Techniques for studying crack morphology, contaminants, and electrochemistry in stress corrosion p0189 N72 21928

Sulfur, sodium, and chloride contaminants in gas turbine engines p0232 N73 23610

### CONTAMINATION

Analytical techniques applied to additive and contaminant analysis in advanced hydrocarbon fuels with sulfur, lead, and fluorine impurities p0171 N72 11673

### CONTINUOUS RADIATION

MHF bistatic CW aerial backscattering and influence of daytime, seasonal, and geographic latitude p0127 N72 21128

### CONTINUOUS WAVE RADAR

Ultrahigh resolution radar for sensing relative interstructure in troposphere p0123 N72 16101

### CONTINUUM FLOW

A review of supercritical flow from the continuum to the free molecular flow regime p0272 N74 14732

### CONTRAST

Model for inherent contrast conditions in faulted rock objects p0303 N73 19968

### CONTROL EQUIPMENT

Application of active controls to suppression of flutter for supersonic aircraft p0045 N73 17005

### CONTROL SIMULATION

Analysis of digital and analog computer techniques for simulation of missile attitude and control and application of hybrid simulation procedures p0226 N72 27887

### CONTROL SURFACES

Calculation of pressure distributions over wings with highly oscillating control surfaces using an integral method p0009 N71 29346

Application of lifting surface theory to wing with control surfaces in unsteady motion [AGARD R 593] p0053 N71 29347

Asymptotic expansion techniques to define pressure loading effects on wings with articulated control surfaces p0010 N71 29348

Unsteady pressure measurements on harmonically oscillating swept wing with two control surfaces in incompressible flow p0010 N71 29350

### CONTROLLABILITY

Flight testing military transport aircraft for handling and performance in STOL applications p0026 N71 29060

Survey of aerospace industry procedures and various techniques used in engineering, integration of handling qualities, stability, control, and load alleviation devices on structural loads [AGARD R 593] p0040 N73 11020

Flight tests for determining handling qualities and operational characteristics of B-100 aircraft p0054 N73 27068

### CONVECTIVE HEAT TRANSFER

Heat exchangers and forced convection in gas turbine engines p0299 N72 18948

### COOLING SYSTEMS

Advanced cooling systems and heat exchangers for turbine blades of high temperature gas turbine engines [AGARD CP 73 71] p0257 N71 17372

Effectiveness of turbine cooling systems for high temperature [NASA TM X 66702] p0258 N71 17385

Impact cooling method for turbine rotor blades p0260 N71 17397

Heat transfer in liquid metal cooled turbine blades p0260 N71 17398

### CORE STORAGE

Principles of design for data storage for data processing information in small memory systems p0154 N72 11192

Aerospace computer memory technology and application of particular techniques to various system requirements p0156 N72 11218

## COROLIS EFFECT

Stabilization of turbulent shear layer flow in rotating systems by control forces p0180 N72 20305

Braxial simulation involving standard red control stimuli for selection test and rehabilitation of motion sick pilots p0079 N73 21098

## CORROSION

Research organizations, investigations, and programs in high temperature research from eleven NATO countries and Spain [AGARD R 585 71] p0302 N71 36382

Research and development of NATO countries in high temperature corrosion of aerospace alloys p0201 N72 20491

Conference on high temperature corrosion of alloys for aerospace applications [AGARD CP 1201] p0201 N73 23597

High temperature corrosion scale for heat resistant alloys p0201 N73 23598

Performance of aircraft gas turbine components in hot corrosion environments p0201 N73 23599

Thermodynamic stability diagrams of high temperature O<sub>2</sub> corrosion reactions p0201 N73 23602

Comparison of noble alloys and metal alloys relative to hot corrosion resistance p0203 N73 23612

## CORROSION RESISTANCE

Corrosion tests of materials for waste guide valves and turbine blades subject to vanadium containing fuel combustion p0203 N73 23613

Methods of oxidation and corrosion resistance in refractory metal alloys used in gas turbine engines p0203 N73 23617

NATO national reports on high temperature corrosion of aerospace alloys p0201 N73 23618

## CORROSION TESTS

Stress corrosion tests of 7XXX series high strength aluminum alloys in laboratory environment p0285 N72 21903

Stress corrosion tests of titanium alloys and aluminum alloys welded titanium alloys p0287 N72 21912

Pierced beam shear beam and long term beam exposure tests for determining stress corrosion of Al alloys in sea water p0288 N72 21919

Summary of conference on stress corrosion testing methods [AGARD R 521] p0292 N73 18931

## COSMIC RAYS

Biophysical hazards of cosmic radiation during Saturn and manned space flight p0075 N72 26046

Active dosimetry for protection and control of cosmic rays in supersonic aircraft p0075 N72 26047

Passive dosimetry for measuring cosmic radiation dose and its effects during manned space flight p0075 N72 26048

Relative biological effects of heavy cosmic rays on human tissue p0075 N72 26049

Effects of accelerated particles and cosmic rays on flight II: space radiation p0075 N72 26051

Passive dosimetry for cosmic rays in manned space flight p0075 N72 26052

## COST ANALYSIS

Cost effectiveness analysis of aircraft engine p0190 N71 36784

Life cycle cost analysis of integrated navigation systems for aircraft and air-to-surface missiles p0232 N73 20717

Integrated navigation system processing system and cost effectiveness systems p0149 N73 14206

## COST EFFECTIVENESS

Optimizing propulsion systems for turbulent flow p0016 N71 20016

Cost effectiveness of aircraft sale and maintenance p0262 N71 26952

Cost effectiveness of failure analysis and design techniques for measuring reliability of avionics systems [AGARD US 47 71] p0189 N71 36776

Cost effectiveness of fault test process in aircraft operations p0189 N71 36780

Fundamentals of the computer, generator, and program of fault test process in aircraft operations and cost effectiveness of computer system p0117 N71 22553

Operational cost and in-flight development aspects in design of space station and systems p0278 N73 23884

Economics of CAD: A new approach p0165 N74 15908

Technical guide to system testing: basic considerations, tests, and results of computerized testing for system test cost effectiveness p0237 N74 14306

A research worker's view of the future of automatic testing machines p0161 N74 16918

## COST ESTIMATES

Cost estimates as factors of load information analysis p0113 N71 19526

## COST REDUCTION

Cost reduction for a new development of aircraft airframe p0177 N71 16362

Cost reduction and data interchange for reducing data processing costs p0159 N73 24207

## CRASH INJURIES

AGARD Annual Meeting 1973: conference of research and development in science and technology to meet military requirements in reduced costs p0304 N74 21610

Techniques oriented towards cost reduction in aircraft production p0305 N74 21613

The reduction of airframe costs with particular reference to combat aircraft p0305 N74 21615

The hingeless rotor: A concept to increase mission effectiveness at reduced costs p0305 N74 21616

Research work and costs: the role of data processing in aircraft production p0305 N74 21617

Impact of technology on cost reduction in aircraft production p0305 N74 21618

### COST

Profile construction cost benefits, economics, and user surveys in transfer of technology and selective dissemination of information p0301 N71 23506

### COUPLING

Coupling effects between wall heating and axial pressure gradients in turbulent boundary layer flow [NASA CR 125903] p0176 N72 20281

### CRACK INITIATION

Analysis of crack initiation and crack propagation in high strength Al alloys in different environments p0288 N72 21918

Techniques for controlling time to fatigue crack initiation in design of aircraft structures and simulation of residual stress analysis p0295 N73 29910

Application of growth rate data and analytical relationships for predicting crack growth under variable amplitude loading p0295 N73 29932

### CRACK PROPAGATION

Effects of reprecipitation and crack velocity on stress corrosion cracking in alloys p0286 N72 21907

Threshold stress intensity values and crack propagation rates for stress corrosion of high strength steels in aqueous environment p0287 N72 21911

Laboratory equipment for testing stress corrosion of bolt loaded WOL specimens and monitoring crack growth p0287 N72 21914

Methods for determining susceptibility of Zn-Mg-Cu alloy to stress corrosion crack growth p0287 N72 21915

A photoelastic technique for determining crack growth rate in high strength container steel in aqueous environment p0287 N72 21917

Analysis of crack initiation and crack propagation in high strength Al alloys in different environments p0288 N72 21918

Crack growth study and effects of changing specimen geometry and shape on fatigue behavior in the room temperature loading p0291 N73 16898

Fatigue crack propagation under flight simulation loading at 10, 15, and 20 cycles per second p0291 N73 16920

Some recent developments in fatigue crack fracture in microstructural analysis of the timescale of high strength steels p0204 N74 23110

Influence of microstructure on the growth of fatigue cracks: analysis of processes which govern crack propagation rate p0204 N74 23112

### CRACKING/FRACTURING

Application of linear elastic fracture mechanics to developing stress corrosion cracking test standards [NASA TM X 68303] p0286 N72 21906

Crack growth testing for determining susceptibility of high strength alloys to stress corrosion cracking p0287 N72 21911

Microscopic characteristics of stress corrosion cracking in steel with high yield strength p0288 N72 21925

Stress corrosion cracking in steel alloys: a review of stress corrosion cracking p0289 N72 21927

Techniques for studying crack morphology, contaminants, and electrochemistry in stress corrosion p0289 N72 21928

Influence of microstructure on the growth of fatigue cracks: analysis of processes which govern crack propagation rate p0204 N74 23112

### CRASH INJURIES

Linear acceleration of impact type having human injury consequences p0098 N72 19119

Crash injury research and aircraft safety and protection [AGARD CP 88 71] p0098 N72 19120

Biomechanical and human powered applications to occupational problems resulting in crash injuries p0098 N72 19121

Analysis of crash injuries and consequences of low level impact p0098 N72 19123

Exposure to extreme forces through human body and airframe failure p0098 N72 19125

Analysis of crash injuries and consequences of low level impact p0098 N72 19127

Safety device study for crash protection in aircraft p0098 N72 19129

A review of crash protection in aircraft p0098 N72 19131

Crash protection in aircraft p0098 N72 19133

History of aircraft crash protection studies and facilities for crash protection p0098 N72 19135

Properties of materials designed to reduce effects of crash impact on aircraft p0098 N72 19137



- Models for head injury prediction and helmets and prediction of optimum helmet performance p0104 N72 19161
- CRASH LANDING**  
Landing accidents investigations for Hawker Siddeley 748 aircraft with performance measurements on rough surfaces p0028 N71 23417  
Simulated crash tests to assess fire resistance of aircraft fuels containing polymeric additives p0254 N72 11692
- CRASHES**  
Linear and angular acceleration terminology, human acceleration simulation, airplane airbag restraint systems and mathematical models of automobile crash loads p0103 N72 19155
- CREEP STRENGTH**  
Development and conduct of national and international programs to determine variations in creep test techniques and establishment of standard creep test procedures [AGARD R 581 71] p0295 N71 25449
- CROP GROWTH**  
Backscatter properties of ground vegetation for radar waves at X band and L band frequencies p0122 N72 16093
- CRYOGENICS**  
Application of superconducting coils for energy storage and determination of optimizing parameters for inductive energy storage p0064 N73 19042
- CRYSTALLIZATION**  
Influence of surface preparation, surface texture and initial oxidation on metal surface crystallization p0201 N73 23603
- CURVATURE**  
Axisymmetric inlet flow and curvature theories for small gas turbines p0265 N72 16701
- CURVE FITTING**  
Universal curves which relate general properties of two dimensional boundary layers on turbulent thin walled p0268 N73 19795
- CUSHIONS**  
Acceleration protection system design, impact testing of restraint harnesses and ejector seat cushions and applications p0104 N72 19157
- CYBERNETICS**  
Development of schematic representation of pilot workload and functions for various portions of aircraft flight and reaction to various stimuli p0040 N72 32035
- CYCLIC LOADS**  
Effect of environment and stress cycling on in-service structural failure of airframes and procedures for predicting safe operational conditions p0295 N73 29929
- CYLINDRICAL SHELLS**  
Computerized design of stiffened cylindrical shells and ablating composite heat shield p0284 N71 20137
- D**
- D REGION**  
Electromagnetic cross modulation and very low frequency propagation techniques for measuring acoustic gravity waves in ionospheric D region p0137 N73 14153
- DARK ADAPTATION**  
Effects of accelerated particles and cosmic rays on flight flashes in human eye [NASA TM X 68460] p0075 N72 26051
- DARKROOMS**  
Practical problems in clinical nystagmography 1. Guidelines for selection of equipment, facility for vestibular tests p0108 N74 20734
- DATA ACQUISITION**  
Characteristics of electronically accelerated mass spectrometers for satellite applications and analysis of atmospheric data acquisition p0192 N72 19494  
Flight test program and data acquisition techniques for evaluation of Boeing 747 aircraft p0034 N72 20977  
Characteristics of flight test instruments and techniques for overcoming limitations and sources of error p0035 N72 20984  
Development of flight test procedures for use with advanced aircraft to determine cruise performance characteristics p0035 N72 20985  
Comparison of flight test and wind tunnel data to determine areas of agreement when nonlinearities appear in aerodynamic coefficients of slender wing aircraft p0036 N72 20990  
Determination of performance data and stability and control characteristics from aircraft performance under nonsteady flight conditions p0036 N72 20992  
International survey of air pollution by aircraft engines and fuels [AGARD AR 40] p0217 N72 21590  
Development of airborne flight data acquisition and data processing systems [AGARD LS 50] p0195 N73 10450  
In-flight data acquisition and processing systems p0195 N73 10452  
Impact of technological development on airborne data acquisition system and ground data processing station p0195 N73 10457  
Integrated microform machine processing system and costs of using such systems p0159 N73 24206
- DATA PROCESSING TERMINALS**  
Feasibility analysis of packet switching networks for remote access computing systems p0158 N72 22171  
TAM/TAM system for use during oceanic, continental and terminal control area flight p0234 N73 23710
- DATA RECORDING**  
Characteristics of satellite television recording system using continuous line scanning with constant open aperture p0192 N72 19498  
Development of pulse code modulation system for encoding and formatting data using satellite onboard equipment p0193 N72 19503  
Processing of Concorde digitally recorded data p0195 N73 10453  
Data recording and data interchange for reducing data processing costs p0159 N73 24207  
Analysis of structural response to acoustic loading and preparation of data sheets for various conditions of acoustic loads p0293 N73 29914
- DATA REDUCTION**  
Feasibility and applications of scientific and technical information analysis centers [AGARD CP 78 71] p0113 N71 19526  
Concept mission and operation of scientific and technical information analysis centers p0113 N71 19527  
Analysis of deterministic and random flight data p0195 N73 10455  
Use of radar recording data for radar target assessment p0145 N74 11965  
The use of RCS data for radar systems design p0145 N74 11966
- DATA SAMPLING**  
Signal to noise ratio performance of optimum digitalized FM demodulator p0131 N73 10195
- DATA STORAGE**  
Development and characteristics of data storage equipment for use on small scientific spacecraft p0193 N72 19502
- Procedures for predicting fatigue life of aircraft flying under various load conditions using data obtained by counting accelerated meter p0294 N72 29927
- Appendix: A data item service for aircraft drag estimation: collection, dissemination and development of aerodynamic drag prediction data p0020 N74 14717
- DATA CONVERTERS**  
Principles of video to digital converter for storage of video information in small memory systems p0154 N72 11197
- DATA LINKS**  
TAM/TAM system for use during oceanic, continental and terminal control area flight p0234 N73 23710
- DATA MANAGEMENT**  
Development of methods for presenting aircraft performance data and comparison of specific methods to show sources of discrepancies p0053 N73 24050  
Information dissemination services to industry p0159 N73 24210
- DATA PROCESSING**  
Feasibility and applications of scientific and technical information analysis centers [AGARD CP 78 71] p0113 N71 19526  
Concept mission and operation of scientific and technical information analysis centers p0113 N71 19527  
Robot data screening process to select relevant variables in data search p0151 N72 11176  
Radar pattern recognition for image data processing with meteorological radar systems p0151 N72 11181  
Development of numerical process for extracting aerodynamic coefficients from flight test data p0036 N72 20991  
Processing of Concorde digitally recorded data p0195 N73 10453  
Analysis of deterministic and random flight data p0195 N73 10455  
Application of computer techniques for determination of flutter characteristics of aircraft and comparison with model matching data analysis [AGARD R 596] p0046 N73 18030  
Three color receptors of human Helmholtz and opponent color types of information processing p0077 N73 19066  
Design of airborne flight data transmission system for automatic acquisition and tracking p0278 N73 23885  
Data recording and data interchange for reducing data processing costs p0159 N73 24207  
Electronic computer processing of data stored in data banks p0159 N73 24212  
Aeromedical research and clinical applications of averaging techniques in nystagmography: computer techniques in precise measurements of average eye movements p0110 N74 20750  
Automated nystagmus analysis technique on eye data processing p0110 N74 20751
- DATA PROCESSING EQUIPMENT**  
Development of airborne flight data acquisition and data processing systems [AGARD LS 50] p0195 N73 10450  
In-flight data acquisition and processing systems p0195 N73 10452  
Selection of dynamic data processing systems p0195 N73 10454  
Impact of technological development on airborne data acquisition system and ground data processing station p0195 N73 10457  
Integrated microform machine processing system and costs of using such systems p0159 N73 24206
- DEBYE SCHRER METHOD**  
Debye polarization theory for determining electromagnetic wave propagation in sea p0241 N73 35022
- DECCELERATION**  
Body dynamics of air blast during acceleration and deceleration events p0100 N72 19134  
Linear deceleration and test vehicle p0103 N72 19151
- DECISION MAKING**  
Robot data screening process to select relevant variables in data search p0151 N72 11176  
Space station information subsystems for automatic support of manned operations p0279 N73 23887  
Simulation of pilot decision making process in manual landing operation during fog p0280 N73 23898  
Mission task simulation for human-machine task sequencing considering pilot performance degradation p0280 N73 23899
- DECISION THEORY**  
The value of a pattern recognition system which is a linear combination of average Michowski distance in decision space p0153 N72 11191
- DEFENSE COMMUNICATIONS SYSTEM (DCS)**  
Operational performance and transmission message methods for wideband Defense Communications System network p0133 N73 10208
- Development and operation of programmable PCM telemetry encoder for data storage and processing during space missions p0193 N72 19504  
Video storage and transmission systems for documentation and dissemination of information conferences [AGARD CP 92] p0157 N72 22168  
Data collection problems for small documentary centers p0159 N73 24208  
Electronic computer processing of data stored in data banks p0159 N73 24212  
Presentation and storage of radar cross section data p0145 N74 11964
- DATA SYSTEMS**  
Development and characteristics of data storage equipment for use on small scientific spacecraft p0193 N72 19502  
Development of pulse code modulation system for encoding and formatting data using satellite onboard equipment p0193 N72 19503  
Development and operation of programmable PCM telemetry encoder for data storage and processing during space missions p0193 N72 19504  
Application of digital computers for automatic testing and data processing during checkout of satellites p0193 N72 19505  
Video storage and transmission systems for documentation and dissemination of information conferences [AGARD CP 92] p0157 N72 22168  
Computer aided input of graphic information on chemical structures by keyboarding under visual control of display device p0157 N72 22170  
Methods employed to obtain datum position and velocity information for evaluation of inertial navigation systems and identification of error sources p0272 N73 20716  
Design of a borne flight data transmission system for automatic acquisition and tracking p0278 N73 23885  
Functions of small industrial information center p0158 N73 24203  
Integrated microform machine processing system and costs of using such systems p0159 N73 24206  
Data collection problems for small documentary centers p0159 N73 24208
- DATA TRANSMISSION**  
Tropospheric turbulence effects on superhigh frequency transmissions at low elevation angles p0116 N71 21422  
Video storage and transmission systems for documentation and dissemination of information conferences [AGARD CP 92] p0157 N72 22168  
Microfilm test access system which automatically retrieves scans and transmits to remote display terminals utilizing wideband transmission network p0157 N72 22169  
Algorithm for reducing redundancy during image transmission p0131 N73 10189  
Noise and alias effects on differential pulse code modulation transmission of sampled aerial imagery p0131 N73 10190  
Automatic equalizers of telephone channels for fast transmission of digital data p0132 N73 10199  
Algorithm for adaptive digital filters of data communication channels p0132 N73 10200  
Real time computerized message switching and data transmission systems for military communications network p0133 N73 10206  
TAM/TAM system for use during oceanic, continental and terminal control area flight p0234 N73 23710  
Fundamental concepts of communication theory to include transmission of continuous signals and use of discrete time signals p0143 N73 32054  
Characteristics of digital communication systems and processing of bandpass digital signals using spread spectrum techniques for data transmission p0143 N73 32055  
Principles and operation of spread spectrum communication system with application to satellite communication systems p0143 N73 32056  
Performance of spread spectrum communication systems to include effects of various forms of channel noise and synchronization aspects of system p0143 N73 32057

**DEFENSE PROGRAM**

Director's annual report to the North Atlantic Military Committee 1971 p0306 N74 23496

**DEFORMATION**

Equations for time mean values of incompressible turbulent flow and eddy viscosity dependence on second invariant of deformation tensor p0176 N72 20280

**DEHYDRATION**

Metabolic imbalances and body hypohydration during food deprivation for 10 days p0070 N71 20368

**DELTA MODULATION**

Normal control of delta-modulated vocal signals in an aviation telecommunication system p0131 N73 10194

**DELTA WINGS**

Self and drag interference characteristics of delta winged nacelles with leading edges p0002 N71 19359

Butterfly effect in chaotic flow around a delta winged aircraft on tandem delta wings with oscillations in supersonic flow p0008 N71 29337

Wind tunnel measurements of Reynolds number effect on force and pressure coefficients for slender delta wing at transonic speed p0012 N72 11801

Constitution of the shock wave front in flow with finite viscosity and slender wing airfoils for nonequilibrium development p0013 N72 11800

Drag of delta bodies for planar airfoils p0014 N74 14731

**DEPLETION**

Stresses and adaptation problems associated with large scale nitrogen depletion in time-averaged ecosystems p0019 N71 20360

**DEPOLARIZATION**

Formulation of a scattering depolarization effects in depolarization statistics for homogeneous and inhomogeneous media p0019 N71 20360

Nonpolarization depolarization of electromagnetic wave in isotropic media p0014 N72 26123

Planar depolarization of linear and circular polarization waves p0014 N72 26122

**DESCENT TRAJECTORIES**

Control and prediction of separated vortex trajectories dropped from a turbopropeller at high speed p0005 N71 19379

Flow field effects of propeller nacelle corners at 6,000 to 12,000 feet using parabolic approximations for the propeller nacelle p0011 N72 19137

**DETACHMENT**

Analysis of the high speed flow separation and reattachment during flight and reattachment in supersonic flow p0012 N72 26042

**DETERIORATION**

Analysis of methods for early stage detection of deterioration in a combustion engine p0014 N72 11698

**DIABETES MELLITUS**

Visible diabetes mellitus in high crewed aircraft Air Force p0008 N72 14129

Statistical analysis of diabetes mellitus in high crewed aircraft p0008 N72 14129

Optimization of diabetes mellitus in high crewed aircraft p0008 N72 14129

The problem of diabetes mellitus in high crewed aircraft p0008 N72 14129

The relationship of diabetes mellitus to high crewed aircraft p0008 N72 14129

**DIAGNOSIS**

Diagnosis and functional characteristics of human muscular fitness p0011 N71 20360

Diagnosis and prognosis of diabetes mellitus in high crewed aircraft p0008 N72 14129

Automated medical diagnosis system for comparison of sequential patterns in medical data p0012 N72 11698

Clinical electrocardiogram in progress of lower extremity ischemia p0014 N72 26123

Technical evaluation report on the use of the delta winged aircraft for high speed flight p0014 N72 26123

Referring to the use of the delta winged aircraft for high speed flight p0014 N72 26123

Value of delta winged aircraft in high speed flight p0014 N72 26123

Analysis of the use of the delta winged aircraft for high speed flight p0014 N72 26123

Flow field effects of propeller nacelle corners at 6,000 to 12,000 feet using parabolic approximations for the propeller nacelle p0011 N72 19137

Flow field effects of propeller nacelle corners at 6,000 to 12,000 feet using parabolic approximations for the propeller nacelle p0011 N72 19137

Flow field effects of propeller nacelle corners at 6,000 to 12,000 feet using parabolic approximations for the propeller nacelle p0011 N72 19137

The molecular structure of the nitrogen p00109 N74 20748

**DIELECTRIC PROPERTIES**

Analysis of radar backscatter from the sea: dielectric properties of materials and short range radar measurements p0126 N72 16119

**DIES**

Stress corrosion behavior of die forgings made from Al-Zn-Mg-Cu alloys p0288 N72 21922

**DIESEL ENGINES**

Comparison of natural gas turbine and diesel engine power plants for aircraft and ground engine propulsion p0262 N71 26458

**DIETS**

The problem of diabetes mellitus in high crewed aircraft p0008 N72 14129

**DIFFERENTIAL EQUATIONS**

Optimization of aerodynamic constraints for a delta wing using differential equation idealization and finite element approximation p0284 N71 20139

Boundary conditions for difference approximation of hyperbolic differential equations p0012 N72 11801

**DIFFRACTION PATTERNS**

Optimal multiple beam systems and improved beam parameters for space communication p0013 N72 11800

Topographic effects on microwave propagation over diffraction patterns p0013 N72 11800

Very high frequency signal fading and the scale path propagation p0013 N72 11800

**DIFFRACTION PATTERNS**

Calculation of diffraction efficiency and signal-to-noise ratio for two-dimensional and volume diffraction gratings p0013 N72 11800

**DIFFUSE RADIATION**

Measurement of light scattering at various angles using point spread function and modulation transfer function techniques p0042 N73 33629

Application of Fourier techniques for accurate spatial resolution of light scattering profiles p0042 N73 33629

**DIFFUSERS**

Projection for predicting performance characteristics of semi-conducting diffusers in optical systems p0083 N73 17259

**DIFFUSION**

Laminar diffusion flames of acetone in oxygen-enriched air p0013 N72 11800

**DIFFUSION THEORY**

Analysis of the problem of diffusion in a fluid medium p0013 N72 11800

Analysis of the problem of diffusion in a fluid medium p0013 N72 11800

**DIGITAL COMPUTERS**

Applications of digital computers for automatic testing and data processing during the flight of vehicles p0013 N72 11800

Applications of digital computers for automatic testing and data processing during the flight of vehicles p0013 N72 11800

Applications of digital computers for automatic testing and data processing during the flight of vehicles p0013 N72 11800

**DIGITAL FILTERS**

Digital filtering procedures for images with a periodic structure p0013 N72 11800

Digital computer techniques for filtering a transmission of telecommunication data p0013 N72 11800

Fast Fourier transform digital processing algorithm for image and data filtering p0013 N72 11800

Automatic extraction of telecommunication data from noisy data p0013 N72 11800

Algorithm for adaptive digital filter data communication channels p0013 N72 11800

Modeling and synthesis of digital filter for a process of communication p0013 N72 11800

**DIGITAL NAVIGATION**

Feasibility evaluation of micro-wave navigation system for high speed aircraft p0013 N72 11800

**DIGITAL SIMULATION**

Mathematical models for simulation of communication systems p0013 N72 11800

**DIGITAL SYSTEMS**

Advanced digital systems for communication systems for telecommunication and video storage p0013 N72 11800

Digital telecommunication systems for a network of aircraft p0013 N72 11800

The NASA computer system for high speed aircraft p0013 N72 11800

Digital telecommunication systems for a network of aircraft p0013 N72 11800

**DIGITAL TECHNIQUES**

Conference on expanded aerospace telecommunication system requirements and digital data transmission methods p0130 N73 10187

Conference on expanded aerospace telecommunication system requirements and digital data transmission methods p0130 N73 10187

Conference on expanded aerospace telecommunication system requirements and digital data transmission methods p0130 N73 10187

**DISCRETE FUNCTIONS**

Discrete functions for calculating normal wash in supersonic flow p0008 N72 14129

**DISEASES**

Symptoms of central nervous system after long flying times p0083 N73 17259

**DISORDERS**

Nasal and oral disorders and flight fitness in German armed forces p0097 N72 14107

**DISORIENTATION**

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

Relationship between disorientation and aspects of spatial orientation and effects of spatial disorientation p0013 N72 11800

- Hybrid character generator combining stroke writing and  
displays procedure for anthropotechnical evaluation of  
integrated displays p0224 N72 22628
- Assessment of design aircraft cockpit layout and  
display control system p0224 N72 22629
- Design guidelines for pictorial integrated flight control  
and guidance displays for V-STOL aircraft  
(NASA CR 126153) p0224 N72 22630
- Evaluation of integrated flight display for hovering phase  
of IFR landing of V/STOL aircraft p0224 N72 22631
- V-STOL display requirements for approach and landing  
under adverse weather conditions p0224 N72 22632
- Harrier aircraft navigation display and computer unit with  
projected moving map means of storing and selecting  
coordinates and numerical data superimposed on map  
p0224 N72 22633
- Airborne map display systems using direct view, projected  
combined map, CRT and electronically generated map  
displays p0224 N72 22634
- Electronic head up display systems for military aircraft  
p0225 N72 22635
- Engineering and operational factors of electronic multisensory aircraft displays p0225 N72 22636
- Solid state electroluminescent materials for display  
devices p0225 N72 22638
- Multipurpose wide field three dimensional head up  
display for aircraft pilots during approach and landing and  
other maneuvers involving altitude changes p0225 N72 22639
- Display principle for 3-D or multicolor solid state 2-D  
panel displays p0225 N72 22640
- Spacecraft display technology applied to aircraft guidance  
and control displays p0225 N72 22641
- A variety of vertical contact analog display in simulating  
carrier landings and error contributed by display resolution  
temporal masking and control complexity p0225 N72 22642
- Rate of closure as performance monitoring parameter  
during approach and landing p0226 N72 22643
- Flight test data on an electroluminescent light display  
panel in aircraft cockpit p0226 N72 22644
- Display design for guidance and control  
(AGARD R 943) p0194 N72 22649
- Display systems for all weather terminal operational  
capability of V-STOL aircraft p0196 N73 11497
- (AGARD R 954) p0196 N73 11497
- Analysis of aircraft instruments and display devices for  
approach control and landing of V-STOL aircraft  
(AGARD R 954) p0196 N73 11497
- DISTANCE MEASURING EQUIPMENT**
- Integrated SAVVAN VOR and DME system for locating  
a V controlling high altitude aircraft p0237 N73 23695
- DISTORTION**
- Forebody and forebody wing configuration data for  
supersonic inlet performance and distortion for supersonic  
wing flight p0266 N72 16719
- DIURNAL VARIATIONS**
- Diurnal variations in ionospheric critical magnetic dip  
equator due to gravity waves p0138 N73 14160
- DIVING (UNDERWATER)**
- Curvatures of vertical isopycnal surfaces at 1  
among underwater divers with theoretical explanations of  
etiology involved p0072 N72 25943
- The use of cystography in aviation medicine  
aerospace medicine meeting on cystography  
(AGARD CP 128) p0197 N74 20737
- Vertigo in diving p0197 N74 20753
- CCN and vestibular reflexes during diving - inner  
ear damage and auditory deficits p0197 N74 20754
- DO-31 AIRCRAFT**
- Flight tests of V-STOL aircraft DO-31 p0035 N72 26981
- Analysis of aerodynamic characteristics of V-STOL aircraft  
DO-31E V-STOL aircraft characteristics compared with others  
contained in handling requirements documents p0035 N72 32024
- Design development and characteristics of DO-31  
V-STOL aircraft to meet the solution of operational problems  
caused by ground effect and transition flight p0054 N73 27694
- DOCUMENT STORAGE**
- Microfilm text storage systems which automatically  
retrieve, store, and transmit information display terminals  
during wide area and transoceanic network p0157 N72 22149
- DOCUMENTATION**
- Organizational methods and effectiveness of specialized  
documentation systems p0113 N72 19523
- Video storage and display systems for the use of  
text and picture stored information on television  
(AGARD CP 92) p0152 N72 22158
- Design and development of graphic information systems  
displayed by keyboard, graphic calculator and display  
terminal p0152 N72 22159
- DOCUMENTS**
- Document annual report to the North Atlantic Treaty  
Committee 1972 p0036 N72 24494
- DOGS**
- Effects of pressure on anaerobic metabolism in man  
experimental and practical consequences on dogs for flight  
and diving p0036 N72 24494
- (NASA CR 12719) p0036 N72 24494

**DOPPLER EFFECT**

- Antenna response patterns Doppler spectra and  
amplitude distributions of transhorizontal microwave scatter  
propagation p0117 N71 23453
- Development and characteristics of laser Doppler velocity  
instrument to measure velocity of flowing fluids p0200 N72 25505
- Development and characteristics of dual scatter laser  
Doppler velocimeter for flow distribution measurement in  
wind tunnels helicopter downwash and across high lift  
wing sections p0200 N72 25506

**DOPPLER NAVIGATION**

- Possibilities and limitations of rotary and fixed wing  
compatible Doppler sensor designs p0031 N72 11923
- Advanced Doppler inertial navigation system for transport  
helicopters p0033 N72 11935
- Navigation guidance computer requirements for integrated  
navigation system using combination of outputs of  
inertial Doppler and inertial equipment p0157 N72 21224
- Development of Doppler microwave landing system and  
techniques for eliminating effects of multipath transmissions p0234 N73 23706

**DOPPLER RADAR**

- Possibilities and limitations of pattern recognition techniques with  
Doppler radar for detection of personnel moving at rate  
comparable with clutter producing environment p0152 N72 11182
- Development of optical strations and Doppler spectrum  
broadening due to barium plasmas in ionosphere p0128 N72 21135

**DOSEAGE**

- Effects of human biorhythms on chemotherapy and drug  
evaluation p0082 N73 21119

**DOSIMETERS**

- Active dosimetry for protection and control of cosmic  
rays in supersonic aircraft p0075 N72 26047
- Passive dosimetry for measuring cosmic radiation dose and  
its effects during manned space flight p0075 N72 26048
- Passive dosimetry for monitoring of cosmic radiation dose  
rate aboard French prototype of Concorde P01 supersonic  
transport aircraft p0075 N72 26052

**DOUBLE PRECISION ARITHMETIC**

- Data word length considerations for analog and computer  
implementation to obtain required precision levels p0156 N72 21217

**DOWNWASH**

- Numerical analysis of downwash interference on wings  
of transport aircraft p0022 N71 20360
- Numerical method for evaluating downwash on down-  
wash distribution for steady flow over swept airfoils in  
wings p0010 N71 29349
- Development of interaction theory for predicting  
time averaged downwash distribution and response  
characteristics of net propellers in forward flight p0049 N73 21033
- Analysis of unsteady aerodynamic loading on reference  
section of helicopter rotor blades in axial or hovering flight  
under compressible flow conditions p0050 N73 21044

**DRAG MEASUREMENT**

- Procedures for calculating normal wash in supersonic  
configuration and interference between wings and bodies p0068 N73 29345
- A survey of drag prediction techniques applicable to  
subsonic and transonic aircraft design p0019 N74 14711
- Analysis of drag and lift of general body shapes at  
subsonic transonic and supersonic Mach numbers p0019 N74 14712
- On some basic and new aspects about the drag problem  
of wings and bodies in supersonic flows p0019 N74 14713
- Measurements of the drag of some transonic aircraft  
exceedences immersed in turbulent boundary layers p0019 N74 14714
- Method of extending the drag of a full scale  
simulation of flight test data and scale model test data p0019 N74 14715
- Aircraft drag prediction for project approach and performance  
analysis p0019 N74 14716
- Review of methods for predicting wing drag p0019 N74 14717
- Review of methods for predicting airfoil drag p0019 N74 14718
- Drag of aircraft airfoils compared with experimental  
data with transonic airfoil drag data p0019 N74 14719
- Comparison of various methods for calculating profile  
drag from pressure measurements in the wake of  
subsonic airfoils p0019 N74 14721
- Drag and separation effects of separated flow in  
airfoil drag p0019 N74 14722
- New investigations for reducing the base drag of wings  
with a blunt trailing edge effects of splitter plates and  
splitter wedges on aerodynamic drag coefficient p0020 N74 14723
- Review of drag measurements from lightless of liquid  
crystal with comparison to wind tunnel results p0020 N74 14724
- An assessment of the accuracy of transonic drag  
measurements and a comparison with transonic aerodynamic  
coefficients of bodies of revolution from a theoretical  
method p0020 N74 14725
- Drag reduction effects of transonic airfoils p0020 N74 14726
- Measurement of drag and skin friction p0020 N74 14727

**DRAG REDUCTION**

- On some basic and new aspects about the drag problem  
of wings and bodies in supersonic flows p0019 N74 14713
- New investigations for reducing the base drag of wings  
with a blunt trailing edge effects of splitter plates and  
splitter wedges on aerodynamic drag coefficients p0020 N74 14723
- The drag of externally carried stores Its prediction and  
reduction drag reduction by redesign or development  
of new aircraft installations p0021 N74 14729
- DROP SIZE**
- Ground contamination by fuel jettisoned from aircraft  
p0218 N74 14285
- DROP TESTS**
- Photographic recording of aerodynamic interference in  
wind tunnel simulation of jettisoned drop loads from  
aircraft p0065 N73 19378
- DROPS (LIQUIDS)**
- Ground contamination by fuel jettisoned from aircraft  
p0218 N74 14285
- DROSOPHILA**
- Natural ionizing radiation effects on multiplication of  
unicellular organisms and Drosophila melanogaster develop-  
ment p0035 N72 26050
- DRUGS**
- Effects of education and pharmacology on adaptability  
of human beings to degraded sensory environments p0069 N73 20364
- Methamphetamine and Meclonidine under double blind comparison  
test conditions against motion sickness p0079 N73 21100
- Conference on drug evaluation and testing of  
drugs and alcohol in flying personnel and effects on  
flight fitness p0079 N73 21101
- (AGARD CP 108) p0079 N73 21101
- Drug screening data for evaluation personnel efficiency  
by analysts p0080 N73 21104
- Residual effects of hypnotic drugs on human locomotion  
and performance p0080 N73 21106
- Past performance and sleep patterns in long duration  
flights and control of hypnotic drug and alcohol use p0080 N73 21107
- Physiological aspects of sleep induction in man after  
prolonged flight times p0080 N73 21108
- Adaptive tracking task for evaluating drug after effects  
on human flight performance p0080 N73 21109
- Effects of somnolent treatment on pilot performance  
p0080 N73 21111
- Sensitivity of parameters necessary for man-machine  
competitive form p0081 N73 21114
- Review of methodology for detection of abuse and  
therapeutic drug use p0081 N73 21117
- Optimal drug administration of antinausea drugs after  
the performance of navigation personnel p0082 N73 21122
- Influence of alcohol and drugs on aircraft navigation  
in cockpits and in cockpits p0082 N73 21125
- DUCTED FLOW**
- One and two dimensional theories for analyzing ducted mixing  
and burning of gaseous streams p0183 N73 17253
- DUCTS**
- Electromagnetic pulse propagation in ducts between  
ground and atmospheric layer p0116 N73 21425
- Ray tracing analysis of duct effect in line of sight wave  
propagation above sea surface p0116 N73 21428
- Role of atmospheric ducts in the phenomena of radio-  
wave over large distances p0146 N74 13449
- Uniqueness properties of elevated layers p0147 N74 13867
- The occurrence of very high field strengths at beyond  
the horizon propagation over sea in the frequency range  
60-5000 MHz p0147 N74 13868
- Explanation of very low field strength levels on line  
of sight paths over sea due to meteorological conditions  
p0148 N74 13868

**DROPS (LIQUIDS)**

- Ground contamination by fuel jettisoned from aircraft  
p0218 N74 14285

**DROSOPHILA**

- Natural ionizing radiation effects on multiplication of  
unicellular organisms and Drosophila melanogaster develop-  
ment p0035 N72 26050

**DRUGS**

- Effects of education and pharmacology on adaptability  
of human beings to degraded sensory environments p0069 N73 20364
- Methamphetamine and Meclonidine under double blind comparison  
test conditions against motion sickness p0079 N73 21100
- Conference on drug evaluation and testing of  
drugs and alcohol in flying personnel and effects on  
flight fitness p0079 N73 21101
- (AGARD CP 108) p0079 N73 21101
- Drug screening data for evaluation personnel efficiency  
by analysts p0080 N73 21104
- Residual effects of hypnotic drugs on human locomotion  
and performance p0080 N73 21106
- Past performance and sleep patterns in long duration  
flights and control of hypnotic drug and alcohol use p0080 N73 21107
- Physiological aspects of sleep induction in man after  
prolonged flight times p0080 N73 21108
- Adaptive tracking task for evaluating drug after effects  
on human flight performance p0080 N73 21109
- Effects of somnolent treatment on pilot performance  
p0080 N73 21111
- Sensitivity of parameters necessary for man-machine  
competitive form p0081 N73 21114
- Review of methodology for detection of abuse and  
therapeutic drug use p0081 N73 21117
- Optimal drug administration of antinausea drugs after  
the performance of navigation personnel p0082 N73 21122
- Influence of alcohol and drugs on aircraft navigation  
in cockpits and in cockpits p0082 N73 21125
- DUCTED FLOW**
- One and two dimensional theories for analyzing ducted mixing  
and burning of gaseous streams p0183 N73 17253
- DUCTS**
- Electromagnetic pulse propagation in ducts between  
ground and atmospheric layer p0116 N73 21425
- Ray tracing analysis of duct effect in line of sight wave  
propagation above sea surface p0116 N73 21428
- Role of atmospheric ducts in the phenomena of radio-  
wave over large distances p0146 N74 13449
- Uniqueness properties of elevated layers p0147 N74 13867
- The occurrence of very high field strengths at beyond  
the horizon propagation over sea in the frequency range  
60-5000 MHz p0147 N74 13868
- Explanation of very low field strength levels on line  
of sight paths over sea due to meteorological conditions  
p0148 N74 13868
- DYNAMIC CHARACTERISTICS**
- Dynamic characteristics and linear control theory for  
aircraft simulation p0173 N73 16061
- Inter steady state and dynamic performance tests with  
F-111A and F-12 aircraft p0265 N72 16709
- (NASA TM X 6749) p0265 N72 16709
- Mathematical models for measuring operating forces  
and performance of gyroscopes with two degrees of  
freedom p0229 N73 20696
- Dynamic finite state measurement of RCS p0144 N74 13819
- DYNAMIC CONTROL**
- Mathematical modeling of aircraft drag drag coefficient  
model by a linear control system p0002 N72 21212
- Extended dynamic range for real time measurement of  
process control in drag systems p0029 N73 23892
- DYNAMIC MODULUS OF ELASTICITY**
- Ultimate measurement of dynamic modulus of elasticity  
p0029 N72 22494
- DYNAMIC PROGRAMMING**
- Problem solving using dynamic programming for  
pattern recognition in dynamic control systems p0155 N72 22156
- DYNAMIC RESPONSE**
- Transfer function models of drag coefficient drag coefficient  
model by a linear control system p0002 N72 21212
- (NASA TM X 6749) p0002 N72 21212
- Transfer function models of drag coefficient drag coefficient  
model by a linear control system p0002 N72 21212



## ELECTROMAGNETIC MEASUREMENT

Statistics of high level beyond horizon signals at 2.2 GHz and 2.6 GHz and measurement of the variation of the arrival angle structure radio interference and tropospheric scatter. p0148 N74 13866

## ELECTROMAGNETIC MEASUREMENT

Electromagnetic cross modulation and very low frequency propagation techniques for measuring acoustic gravity waves in ionospheric D region. p0137 N73 14153

## ELECTROMAGNETIC NOISE

Performance of spread spectrum communication systems to include effects of various forms of channel noise and synchronization aspects of system. p0143 N73 32057

## ELECTROMAGNETIC PULSES

Electromagnetic pulse propagation in duct between ground and atmospheric layer. p0116 N71 21425

## ELECTROMAGNETIC RADIATION

Biological effects of UHF electromagnetic radar emissions on human organism. p0078 N72 26053  
Navy research and instrumentation for analyzing nonionizing radiation effects on human personnel. p0076 N72 26054

Comparison of ionospheric radio wave propagation and acoustic gravity wave propagation. p0134 N73 14132  
Analysis of random design techniques and development of specifications for random construction. [AGARD AR 53]. p0140 N73 23108

Debye polarization theory for determining electromagnetic wave propagation in sea. p0241 N73 33622

## ELECTROMAGNETIC SCATTERING

Radio wave scattering from auroral ionization. [NASA TM X 68302]. p0127 N72 21131  
Intensity of weak scattering from electron density irregularities in ionosphere. p0128 N72 21134  
Simulation and investigation of scattering mechanisms of radio aurora. p0128 N72 21135

## ELECTROMAGNETIC WAVE TRANSMISSION

Tropospheric characteristics and their effects on electromagnetic wave propagation and radio signal transmission. [AGARD CP 70 71 PT 1]. p0114 N71 21409  
Tropospheric scattering and delay effects on electromagnetic wave propagation in space communications. p0114 N71 21413

Electromagnetic pulse propagation in duct between ground and atmospheric layer. p0116 N71 21425  
Ray tracing analysis on duct effect in line of sight wave propagation above sea surface. p0116 N71 21428

Atmospheric stratification causing anomalous signal propagation at 170 and 5000 MHz over sea surface beyond horizon. p0116 N71 21429  
Perturbation method for calculating surface roughness effects on electromagnetic wave propagation in inhomogeneous atmosphere. p0117 N71 21432

Transmission loss in tropospheric waveguide propagation on 12 GHz scatter link. p0118 N71 23458  
Effects of atmospheric layers on remote sensing by electromagnetic wave reflections. p0123 N72 16098

Geometrical optics solution for plane electromagnetic wave propagation and reflection in inhomogeneous isotropic medium. p0123 N72 16100  
Conference on acoustic gravity wave effects in atmospheric transmission of radio communication signals. [AGARD CP 115]. p0134 N73 14131

Asymptotic analysis of sound wave generation and downward propagation into lower atmosphere. p0134 N73 14134  
Mathematical model for acoustic gravity wave excitation by global masses. p0134 N73 14135

Thermal plasma perturbation model for calculating coupling effects between a quasi-gravity waves and electromagnetic waves in ionosphere distribution. p0133 N73 14167

Explanation of very low level strength reduction of light paths over sea due to meteorological conditions. p0146 N74 13868

## ELECTROMAGNETISM

Debye polarization theory for determining electromagnetic of a surface. p0241 N73 33620

## ELECTROMYOGRAPHY

Clinical electromyography in prognosis of lower motor neuron lesions. p0074 N72 25058

## ELECTRON BEAM WELDING

Stress-strain tests of titanium alloys and electron beam welded titanium alloys. p0287 N72 21912

## ELECTRON DENSITY (CONCENTRATION)

Intensity of weak scattering from electron density irregularities in ionosphere. p0128 N72 21134  
Radio signals from Explorer 22 for ionospheric electron content. p0128 N72 21141

Full wave solution for electron density perturbations caused by gravity waves in F2 region. p0136 N73 14145  
Numerical models of total electron content over Europe and the Mediterranean and middle station oscillations and scintillations. [AGARD AG 16-A]. p0187 N74 14084

A numerical model of TEC over Europe for various meteorological conditions. 2. p0187 N74 14085  
A numerical model of TEC over the Mediterranean area. p0187 N74 14086

Electronics and space activities in Germany wave propagation and electron density research. p0105 N74 21612

## ELECTRON MICROSCOPES

Application of scanning electron microscopy for failure analysis and nondestructive tests of semiconductor devices. p0191 N72 19488

## ELECTRONIC EQUIPMENT

Techniques for determining reliability of electronic equipment after acceleration tests. p0190 N71 36786  
Systems performance and safety in helicopter approach and landing and radioelectronic guidance array. p0034 N72 11939

Development and characteristics of microelectronic equipment for improved reliability and reduced weight and size of electronic components. p0191 N72 19484

Characteristics of solid state power amplifiers for direct amplification using doublers and triplers and application to interplanetary space probes. p0194 N72 19510

Human perceptual characteristics data relating to individual electronic flight display design. p0223 N72 22627  
Tradeoffs between luminance and color coding in electronic aircraft displays and experiments involving immediate response tracking tachistoscope and human judgement. p0223 N72 22623

Electronic head up display systems for military aircraft. p0225 N72 22635  
Engineering and operational factors of electronic multi-sensor aircraft displays. p0225 N72 22636

Research activities of electronic laboratory in development of inertial navigation systems to include applications for space missions and commercial aviation. p0227 N73 20686

Tactical integrated electronic systems for Swedish military aircraft. p0279 N73 23889  
Computerized design of fighter aircraft cockpit electronic control system consisting of main machine interaction. p0281 N73 23905

Computer aided design for electronic circuits conference. [AGARD CP 130]. p0165 N74 13906  
Computer aided design for maximum production yield or maximum reliability. p0165 N74 13911

Electronics and space activities in Greece wave propagation and electron density research. p0305 N74 21612

## ELECTRONIC MODULES

Hybrid microcircuit technology for spacecraft electronic equipment to improve reliability and service life. p0191 N72 19485  
Systems design for spacecraft computer engineering module. p0280 N73 23894

## ELECTRONIC RECORDING SYSTEMS

Practical problems in clinical cystnography. 2. Summary of 210. p0108 N74 20325  
Effects of elevated intracranial pressure on the vestibular system human vertigo due to pressure changes in Eustachian tubes. p0110 N74 20355

## ELECTRONICS

Method for comparing photo electronic and photographic detectors based on product of signal to noise ratio times spatial bandwidth. p0242 N73 33634  
Techniques for long range vision underwater using range gating and threshold with parallax techniques. p0247 N73 33636

## ELECTRONS

Total electron content of ionosphere with emphasis on North Atlantic region. [AGARD AG 16B]. p0187 N73 22350

## ELECTROSTATIC CHARGE

Electrostatic charging in handling of aviation fuels resulting in secondary static discharges. p0153 N72 11686

## ELECTROSTATIC GYROSCOPES

Mathematical models for measuring mechanical qualities of spherical quartz resonators with electrostatic suspension. p0228 N73 20693  
Development of electrostatic gyro systems. p0229 N73 20698

## ELECTROSTATIC PROBES

Sequential static electric field probe and electrostatic probe array methods for measuring turbulent wave properties in hypersonic spheres. p0178 N72 20296

## EMULSIONS

Various gelated emulsified fuels for reducing aircraft crash fire hazard. p0253 N72 11689

## ENDOCRINE SECRETIONS

Influence of long duration flight exposure on metabolic and endocrine functions of pilots and navigators. p0106 N73 19152

## ENDOTHERMIC REACTIONS

Calorimetric studies of energy by endothermic reactions of hydrogen peroxide for absorbing sensible and latent heat. p0251 N72 11672

## ENERGY ABSORPTION

Influence of water energy absorption and air water interface on heat transfer at the ice sea. p0241 N73 33623

## ENERGY DISSIPATION

Dissipation rate measurements and correlations of turbulent flow in atmospheric boundary layer flow. p0178 N72 20292

## ENERGY STORAGE

Development of high energy density storage systems with high energy density and application to power conversion and energy storage. p0063 N73 19035  
Application of superconducting systems for energy storage and transmission of nuclear energy parameters by superconducting energy storage. p0064 N74 19042

Physics of the energy storage in energy radiations and discharge from the design of superconducting energy storage elements. p0064 N74 19043

## ENGINE COOLANTS

Cooling advanced engines by endothermic reactions of hydrocarbon fuels by absorbing sensible and latent heat. p0251 N72 11672

## ENGINE DESIGN

Design of gas turbine engines for high operating temperature. p0258 N71 17386  
Operational design criteria for gas turbine engines. p0261 N71 17402

Design and performance of gas turbine engines for helicopters and surface transport vehicles. p0262 N71 26953

Interference problems of aircraft engine integration in aircraft design optimization. p0037 N72 27016

Determination of thrust and drag characteristics for integrated aircraft engine design optimization. p0038 N72 27023

Proceedings of conference on application of composite materials in construction of aerospace vehicles and propulsion systems. [AGARD CP 112]. p0210 N73 27474

Application of reinforced composite materials for construction of aircraft gas turbine engines. p0212 N73 27490  
Production of lamellar and fibrous composite materials from directional solidification of eutectic alloys and application to gas turbine blades and vanes. p0212 N73 27492

Application of directionally solidified eutectics for design and construction of gas turbine engines. p0212 N73 27493  
Directional solidification of eutectic alloys and application to turbine blades and gas turbine engine components. p0213 N73 27494

Session 4 Design Opening remarks combustor design policy making and pollution control. p0220 N74 14297  
Modelization of turbomachine combustors for pollution studies. p0220 N74 14298

## ENGINE FAILURE

Effect of engine failure on aerodynamic characteristics of supersonic aircraft. p0045 N73 17003

## ENGINE INLETS

Transient performance of double flux engine nacelle inlet and afterbody at high Reynolds numbers. p0013 N72 11866  
Analysis of intake noise of turbofan engine and effect on duct structure due to acoustic fatigue. p0293 N73 29916

Assessment of the influence of inlet and afterbody on the performance on total aircraft drag. p0021 N74 14726

## ENGINE MONITORING INSTRUMENTS

AGARD light test instrumentation series Volume 4 The measurement of engine rotation speed. [AGARD AG 160 VOL 4]. p0196 N74 14116

## ENGINE PARTS

Components for low weight small volume aircraft gas turbine engines. p0262 N71 26955  
Performance of aircraft gas turbine components in hot corrosion environments. p0201 N73 23599

Chemical and mechanical properties of aircraft gas turbine engine components. p0201 N73 23600  
Methods of testing rotating components of turbine engines compared with tests on complete turbine engines. [AGARD AG 167]. p0271 N73 26800

## ENGINE TESTS

Development of techniques for evaluating performance of aircraft engines and measurement of significant operating parameters. [NASA TM X 68301]. p0118 N71 23458

Detailed exhaust emission measurements of three different turbofan engine designs. p0212 N74 14216  
Exhaust emission measurements in the GE T64-7 turbofan engine. p0219 N74 14286

## ENGINEERING MANAGEMENT

Advanced NASA and OOD technology management techniques and application to NATO programs for defense and civil needs. p0302 N73 19668

## ENVIRONMENTAL EFFECTS

Effects of environmental stresses on materials used in construction of glider aircraft. p0201 N73 23601  
Environmental toxicological impact of aircraft operations. p0222 N74 14306

## ENVIRONMENTAL POLLUTION

Problems of chemical pollution by aircraft fuel exhaust and its immediate environment. p0218 N74 14281  
Controlled contamination by fuel system and fuel leaks. p0218 N74 14283

Polypropylene and carbon fiber reinforcement of aircraft and methods for repair of damage. p0218 N74 14284

## ENVIRONMENTAL TESTS

Environmental tests of V-501 aircraft with a new propulsion system. [NASA TM X 68303]. p0118 N71 23459

The effects of aircraft fuel on the environment and the effects of human beings on the environment. p0063 N73 19035  
Heat transfer and fluid dynamics in aircraft engine components. p0212 N73 27492

Standardization of test procedures for engine testing across countries including high speed flight tests and heat transfer and fluid dynamics. [AGARD CP 98]. p0285 N72 21910

## SUBJECT INDEX

- Stressing systems and environmental methods used by European Federation on stress corrosion tests p0285 N72 21904
- Analysis of crack initiation and crack propagation in high strength Al alloy in different environments p0288 N72 21918
- Effects of heat treatment, size, specimen type and test environment on two precipitation hardened stainless steels during stress corrosion cracking tests p0288 N72 21923
- High temperature environmental testing of gas metal interactions to simulate severe operating conditions p0202 N73 23606
- ENVIRONMENTS**
- Combined environmental stress effects on human performance p0069 N71 20362
- ENZYMATIC ACTIVITY**
- Clinical observation of massive injury causing serum enzyme activity in man after crash accidents p0101 N72 19138
- EOLIE SATELLITES**
- Passive gravity gradient method for stabilization of Eolie and Eolie satellites p0278 N72 12867
- Small satellite attitude measurement and control system components p0278 N72 12869
- EPOXY RESINS**
- Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials conference [AGARD CP 63 71] p0206 N72 12492
- Linear and nonlinear stress characteristics of epoxy resin composite materials p0207 N72 12496
- Theoretical and experimental determination of elastic constants in silica epoxy composite materials p0207 N72 12497
- Temperature and fiber orientation effects on mechanical behavior of silica dioxide epoxy composite materials p0207 N72 12499
- Axial tension tests for stress-strain response of silica and reinforcing fibers in glass epoxy resin composites p0207 N72 12500
- Electrical conductivity measurements for determining stress-strain time rate of glass fiber reinforced plastic in reinforced plastic materials exposed to water p0208 N72 12505
- Photoelastic investigation of stress distribution within reinforcing fibers of composite materials p0209 N72 12506
- Application of laminar epoxy composite materials for airframe construction with specific development of F-111 structure p0211 N73 27480
- EQUIPMENT SPECIFICATIONS**
- Techniques for determining system and equipment requirements p0190 N71 16783
- Equipment designed for aerodynamic testing of aircraft at supersonic speeds p0202 N72 19145
- High speed performance of aircraft delivery systems, design and evaluation as performed by Canadian Armed Forces p0203 N72 20987
- Experimental and technological development aspects of space shuttle avionics systems p0208 N72 12884
- EQUIVALENT CIRCUITS**
- Analysis of equivalent circuits for signal propagation in circuits of optical amplifiers and optical transmitters p0165 N74 13914
- ERBIUM**
- Neutron irradiation measurement methods for use in the atmosphere p0224 N72 16108
- ERROR ANALYSIS**
- Finite element analysis of stress measurements on thin curved composite materials p0217 N72 12498
- Comparison of procedures for thin film infrared and surface temperature measurements p0124 N72 16105
- Comparison of surface temperature measurements by satellite thermal imaging infrared sensor p0224 N72 16107
- Model error calculation of atmospheric distribution of ionizing systems caused by reflective index of satellite medium p0125 N72 16115
- Comparison of flight test measurements and techniques for system identification and system of error p0215 N72 20984
- Numerical analysis of effects of various parameters affecting accuracy and stability of strapdown inertial navigation systems p0217 N72 12498
- Development and evaluation of failure rate data and reliability techniques for use with low quality data at high speed rates p0218 N73 20697
- Methods for prediction of failure rate data for failure rate data for high altitude navigation systems and identification of failure rates p0232 N73 29716
- Practical problems in aircraft system testing p0108 N74 20735
- Some aspects of error
- ESCAPE SYSTEMS**
- The use of O<sub>2</sub> tanks in escape during aircraft emergencies available to USAF p0202 N72 19114
- Preparation of symptoms of detection, recognition and configuration of emergency system systems for helicopter crew [AGARD AR 62] p0255 N72 11701
- ESRO SATELLITES**
- Practical systems used with ESRO satellites and their systems p0218 N72 12884

- ESTERS**
- Synthesis and properties of aliphatic ester for turbine lubrication in jet aircraft p0254 N72 11696
- Synthetic high temperature lubricants thickened by complex esters for supersonic aircraft p0255 N72 11701
- ESTIMATES**
- Reliability estimation including failure effect analysis of avionics systems p0189 N71 16777
- Regression analysis of estimation tests and system operating data p0189 N71 16778
- Estimating acceleration, vibration and slowness due to rainfall for satellite ground systems p0147 N74 13856
- EULER EQUATIONS OF MOTION**
- Numerical analysis of three dimensional ideal gas flow and Euler equations of motion p0182 N72 27307
- EUROPA 3 LAUNCH VEHICLE**
- Analysis of stimuli and commands subsystem for checkout and inspection of EUROPA 3 launch vehicle p0191 N72 19490
- EUROPE**
- European jet fuel lubricity evaluation p0252 N72 11679
- Stressing systems and environmental methods used by European Federation stress corrosion tests p0285 N72 21904
- Existing position and future prospects of wind tunnels in European research p0172 N73 20209
- [AGARD AR 60] Numerical analysis of total electric content over Europe and the Mediterranean and multi station ventilation comparisons [AGARD AG 166A] p0187 N74 14084
- Multi station observations November 1971 March 1972 p0187 N74 14087
- EUTECTIC ALLOYS**
- Production of laminar and fibrous composite materials from directional solidification of eutectic alloys and application to jet turbine blades and vanes p0212 N73 27492
- Application of directionally solidified eutectic alloys for design and construction of gas turbine engines p0212 N73 27493
- Directional solidification of eutectic alloys and application to turbine blades and gas turbine engine components p0213 N73 27494
- EVOLUTION (DEVELOPMENT)**
- Nature of evolutionary effects in the development of organizational systems p0215 N72 26050
- EXERCISE (PHYSIOLOGY)**
- Age and exercise effects on body composition, muscle strength and cardiovascular function in healthy young men's employees [AMRL TR 70 24] p0268 N71 20300
- Heat tolerance of athletes during exercise in various thermal environments p0270 N71 20366
- Physiological adaptation to the aging stresses of exercise and hypoxemia under acute and chronic exposure to ambient P<sub>50</sub> CO<sub>2</sub> of 21 mm Hg p0270 N71 20370
- Physical fitness of flying personnel and aging effects on flight crew performance [AGARD CP 63 71] p0091 N71 22301
- Physical fitness testing methods for Canadian Forces flying personnel p0091 N71 22305
- Physical exercise effects on stress tolerances of trained and untrained subjects p0091 N71 22306
- Physical exercise and fitness tests for Canadian Air Force flying personnel p0091 N71 22307
- Design, construction and flight test measurements for estimating human tolerance of military personnel p0091 N71 22309
- Physical exercise and environmental control system for aircraft p0091 N71 22310
- Exercise effects on physical fitness of low level flying systems of aging pilot p0092 N71 22311
- Aging effects on military flight crew body composition and physical exercise performance p0091 N71 22316
- EXHAUST GASES**
- Analysis of air pollution caused by aircraft engine exhausts in vicinity of airport and comparison with air pollution in urban areas [AGARD N71 24788]
- Atmospheric Pollution by Aircraft Engines [AGARD CP 124] p0217 N74 14271
- Removal of NO<sub>x</sub> formation by preburner p0217 N74 14272
- United States Department of Transportation research program on high altitude pollution p0217 N74 14273
- Detailed analysis of engine measurements of three different turbofan engine designs p0217 N74 14276
- Photoacoustic measurement of engine exhaust at low and high altitudes p0218 N74 14277
- Effect of water vapor transport on the optical layer stability of a three dimensional detection model with transport p0218 N74 14278
- A new analytical technique for measuring NO<sub>x</sub> from jet engines at altitudes up to 5000 PPM p0218 N74 14280
- Problems of engine air pollution by aircraft The airport and the surrounding environment p0218 N74 14281
- Photoacoustic method of engine exhaust gas analysis p0219 N74 14285
- Estimation of engine exhaust gas analysis p0219 N74 14286
- Estimation of engine exhaust gas analysis p0219 N74 14286
- Estimation of engine exhaust gas analysis p0219 N74 14286

## EYE MOVEMENTS

- Development and verification of an analytical model for predicting emissions from gas turbine engine combustors during low power operation p0220 N74 14295
- Technology for the reduction of aircraft turbine engine exhaust emissions p0221 N74 14300
- A preliminary study on the influence of fuel staging on nitric oxide emissions from gas turbine combustors p0221 N74 14301
- Design and evaluation of combustors for reducing aircraft engine pollution p0221 N74 14302
- Motorist point of view on the effects of low burning rates on pollution p0221 N74 14303
- Aircraft gas turbine pollutant limitations oriented toward minimum effect on engine performance p0221 N74 14304
- Photometric measurements of exhaust smoke trails by jet engines p0221 N74 14305
- Technical evaluation report on AGARD Technical Meeting on Atmospheric Pollution by Aircraft Engines requirement to analyze contribution to air pollution near airports from various sources p0221 N74 14309
- [AGARD AR 63] p0221 N74 14349
- EXHAUST NOZZLES**
- Flight and wind tunnel evaluations of flow field effects on performance of supersonic underwing exhaust nozzle at various speeds [NASA TM X 68887] p0003 N71 19366
- Aircraft altitudes and engine nozzle interference at subsonic, transonic, and supersonic speeds [NASA TM X 68888] p0003 N71 19368
- Inlet engine and exhaust nozzle tests for supersonic propulsion systems [NASA TM X 67494] p0263 N72 16692
- External drag characteristics of jet engine exhausts using wind tunnel tests p0266 N72 16707
- Theoretical study of the residual evolution of printing products in turbine exhausts p0220 N74 14294
- EXHAUST SYSTEMS**
- Reduction of radiated emissions of turbine engine exhaust systems p0251 N72 11675
- Survey of wind tunnel testing procedures for nozzles and exhausts p0263 N72 16688
- EXOSPHERE**
- Spatial distribution of plasma in polar exosphere based on satellite data p0176 N72 21124
- EXPIRED AIR**
- Respiratory gas analyzer for aircrew pulmonary function measurements [NASA TM X 68370] p0014 N72 25057
- EXPLORER 22 SATELLITE**
- Radiation signals from Explorer 22 for atmospheric electron density p0128 N72 21141
- EXPLOSIVES**
- Explosive testing of aircraft engine exhausts including gas turbine engine exhausts p0253 N72 11676
- Evolution of Earth atmospheric edge layer by light of large atmospheric explosions p0136 N71 17147
- EXPLOSIVE WELDING**
- Explosive bonding technique for strengthening aluminum with fibrous wires p0208 N72 12507
- EXPLOSIVES**
- Explosive bonding technique for strengthening aluminum with fibrous wires p0208 N72 12507
- EXTERNAL STORES**
- Computerized prediction of separated store trajectories dropped from fighter aircraft at high speed p0005 N71 19379
- Flight test measurements on a test store and a test store effect is caused by positioning of external stores on a fighter aircraft p0206 N72 19380
- Computerized prediction of flow field interference forces and moments on aircraft stores at subsonic speeds p0006 N71 19385
- Wind tunnel evaluation of lifting body store configurations for optimal flight drag and separation characteristics p0006 N71 19386
- Statistical prediction of external store separation characteristics from aircraft p0006 N71 19388
- Estimation of external store separation characteristics and alternative drag reduction by redesigning development of new aircraft installations p0221 N74 14279
- EXTERNALLY BLOWN FLAPS**
- Design aspects of stall of powered lift aircraft with externally blown flaps and methods for performance improvement in optimum lift coefficient due to power p0042 N73 15011
- EXTREMUM VALUES**
- Comparative frequency distributions determined by extreme value analysis used for fatigue analysis and interpretation of test data at acceleration and gust velocity measured on transport aircraft [AGARD R 579 71] p0030 N71 25080
- EYE EXAMINATIONS**
- Standardization of tests and classification of color perception abnormalities in military personnel p0211 N72 19011
- EYE MOVEMENTS**
- Neurophysiological factors in visual search performance in tracking a target in a visual display p0216 N72 26056
- Application of water vapor to visual search performance in a visual display p0216 N72 26056
- Modeling of human eye movement in a visual display performance based on physiological parameters of eye p0216 N72 26056

## F REGION

Nystagmography. A useful tool in basic and applied investigations of human neurophysiological system. p0108 N74 20741  
Human eye movements during various forms of linear acceleration and weightless less. nystagmographic recordings of human and fish responses to gravitational conditions. p0109 N74 20747

## F

## F REGION

Intensity variations in satellite scintillations in F region. p0128 N72 21138  
High frequency backscatter observations of high latitude field aligned irregularities in F region. p0130 N72 21149  
F layer electron density fluctuations and disturbances following nuclear explosion at atmospheric height. p0140 N73 14169  
Multi station observations. November 1971. March 1972. p0187 N74 14047

## F2 REGION

Full wave solution for electron density perturbations caused by gravity waves in F2 region. p0136 N73 14145

## F2 AIRCRAFT

Flight test measurements on interference and aerodynamic drag effects caused by self-spraying of external stores from F2 aircraft. p0006 N71 19384

## F14 AIRCRAFT

Role of flight simulation in development of F-14 and F-14 aircraft. p0045 N73 17001

## F28 TRANSPORT AIRCRAFT

Aeroelastic and flutter analysis for F-28 of Foster F-28. p0009 N71 29344  
Development of F-28 transport aircraft wing and analysis characteristics to show effects of boundary layer fences. p0043 N73 15015

## F104 AIRCRAFT

Calculating eigenfrequencies modes and generalized matrices for F-104 aircraft from drawings by finite element method. p0290 N71 21131  
The human factor in F-104 aircraft accident path. statistical analysis of CF-104 aircraft accident patterns. p0107 N74 18800

## F111 AIRCRAFT

Inter steady state and dynamic performance tests with F-111A and YF-12 aircraft. p0266 N72 16709  
Analysis of static and post static characteristics of F-111 aircraft and development of regression techniques to obtain aerodynamic derivatives. p0043 N73 15013  
Application of boron epoxy composite materials for airframe construction with specific development of F-111 stabilizer. p0211 N73 27480

## FAILURE ANALYSIS

Optimum structural design and reliability analysis. p0284 N71 20138  
Cost effectiveness failure analysis and design techniques for measuring reliability of avionics systems. p0189 N71 36176  
[AGARD LS 47 71] Reliability estimation including failure effect analysis of avionics systems. p0189 N71 36177  
Failure of welded joints in Al-2024 aluminum alloy in C-141 cargo. p0289 N72 21929  
Ultrasonic radiographic eddy current and acoustic emission techniques for nondestructive tests of carbon fiber reinforced polymers and failure mechanisms. p0290 N72 24935  
Correlation between full scale fatigue test failures and actual service failures for several military aircraft. p0291 N73 16901  
Failure analysis of four reinforced composite engine case using distributional energy and maximum strain theories of failure. p0213 N73 27570  
Techniques for controlling time to failure crack initiation in design of aircraft structures and application of residual stress analyses. p0295 N73 29130  
Development of rational analysis theory for analyzing fatigue of airframes based on maximum stress field parameter and maximum load excursion ratio. p029 N73 29911  
Application of growth rate data and analytical retardation models for predicting crack growth under variable amplitude loading. p0295 N73 29937  
Analysis of errors in fatigue life prediction procedures and methods for improving accuracy of prediction analysis techniques. p0295 N73 29934

## FAILURE MODES

Development and evaluation of failure detection and isolation techniques for use with four simulated sensor measuring units. p0228 N73 20597

## FAN IN WING AIRCRAFT

Flow distribution and performance measurements on F-12 in an air wing model for range of forward speeds and range of attack settings in crossed wind tunnel. p0265 N72 15702

## FANS

Design, fabrication and test of boron polyimide reinforced titanium fan disks to operate at high temperatures. p0213 N73 21498

## FAST FOURIER TRANSFORMATIONS

Edge detection algorithms. Two dimensional Fourier transforms and edge detection methods for computer processing of natural scenes. p0152 N72 11186

Fast Fourier transform digital processor as spectrum analyzer and adaptive filter. p0132 N73 10198

## FATIGUE (MATERIALS)

Cumulative frequency distributions determined by extreme value analysis used for fatigue analysis and interpretation of mechanical vibration and gust velocity measured on transport aircraft. p0330 N71 25080  
Techniques, applications and scope of fractography. [AGARD AG 155 71] p0285 N72 13882  
Survey and analysis of literature on fatigue damage accumulation in aircraft materials and structures. [AGARD AG 157] p0290 N72 22918  
Effects of testing on fatigue of materials and development of anti-fracturing compounds and metal working procedures to reduce fretting. [AGARD AR 45] p0290 N72 28902  
Physical aspects of fatigue damage accumulation including interaction and sequence effects. p0291 N73 15899

Fatigue crack propagation under flight simulation loading at 10, 1 and 0.1 cycles per second. p0291 N73 16900  
Random fatigue tests on commercial carbon steel with 0.7 percent carbon. p0291 N73 16902

Application of composite materials for structural purposes to show limitations and failure characteristics. p0211 N73 27481

Summaries of papers presented to AGARD conference on random load fatigue. [AGARD AR 54] p0292 N73 28884

Analysis of response and fatigue characteristics of light alloy integrally machined planks with emphasis on acoustic fatigue properties. p0293 N73 29912

Analysis of effect of damping on response of structure to acoustic excitation and experimental method for determining damping coefficients. p0295 N73 29917

Some fatigue characteristics of titanium sandwiche structures and numerical analysis of natural frequencies and static stress values. p0293 N73 29919

Structural response and endurance tests of aircraft structural components to determine effects of critical environment on static fatigue. p0294 N73 29920

Development of procedures for predicting fatigue life of aircraft structures based on fracture mechanics crack propagation and residual static strength analysis. [AGARD LS 62] p0294 N73 29924

Development of fatigue life prediction procedures based on measured stress time histories and mathematical model for descriptions of random vibrations. p0294 N73 29926

Techniques for controlling time to fatigue crack initiation in design of aircraft structures and application of residual stress analyses. p0295 N73 29930

Development of procedure for estimating fatigue life of airframes to eliminate errors caused by neglecting effects of stress redistribution after localized yielding. p0295 N73 29933

Some considerations of the influence of fatigue in the design of strike aircraft. p0060 N74 19653  
Fatigue design of strike aircraft. p0060 N74 19654  
Fatigue and fracture considerations for tactical aircraft. p0060 N74 19656

The metallurgical aspects of fatigue and fracture toughness. Effects of the destructive test on mechanical properties of airframes and construction materials. p0204 N74 23109

Influence of microstructure on the growth of fatigue cracks. Analysis of processes which govern crack propagation rate. p0204 N74 23112

## FATIGUE LIFE

Stress-strain fatigue behavior of titanium reinforced aluminum composite bearing strength of both surfaces. p0208 N72 12504

The potential of stress-strain relationships for determining stress-strain time life of glass fiber reinforced plastic bonded reinforced plastic materials exposed to water. p0208 N72 12505

Random load fatigue of aircraft structures under excitation. [AGARD CP 118] p0291 N73 16896

Fatigue life assessment of aircraft structures based on random air programmed fatigue tests and loadings. p0291 N73 16897

Crack growth study and effects of change in spectrum severity and shape on fatigue behavior under random loading. p0291 N73 16898

Fatigue life prediction of military aircraft under three different test spectra. p0291 N73 16903

Computerized methodology for fatigue analysis. Basic computer based computer program for determining fatigue design loads. p0056 N74 10910

Design against fatigue. Consideration of the fatigue life assessment of tactical aircraft. p0060 N74 19652

Effect of fatigue requirements for tactical fatigue life prediction. p0061 N74 19657

## FATIGUE TESTS

Some guidelines for testing of high frequency tests. [AGARD P 604] p0297 N73 8916

Development of method for determining response of two types of joints subjected to high intensity dynamic loading. p0293 N73 29915

Some fatigue characteristics of titanium sandwiche structures and numerical analysis of natural frequencies and static stress values. p0293 N73 29919

Acoustic fatigue tests of aluminum alloy structural elements under narrow band random loading with zero mean stress in skin. p0294 N73 29921

Development of experimental programs for determining response and some fatigue resistance of lightweight aircraft structures. p0294 N73 29923

Development of procedures for predicting fatigue life of aircraft structures based on fracture mechanics crack propagation and residual static strength analysis. [AGARD LS 62] p0294 N73 29924

Procedures for evaluating fatigue quality of aircraft structures based on fatigue life crack propagation and residual strength. p0294 N73 29925

Procedures for predicting fatigue life of aircraft flying under various load conditions using data obtained by counting accelerometer. p0294 N73 29927

Structural fatigue analysis and testing for fighter aircraft. p0060 N74 19655

The role of the major fatigue test in the acceptance certification and safe utilization of strike aircraft. p0061 N74 19658

Re assessment of fatigue performance of fighter aircraft. p0061 N74 19659

Designers need for general information from analysis of fatigue test results and service behavior. p0061 N74 19660

## FEAR OF FLYING

Fear of flying and its treatment. In military pilots. p0088 N74 18781

Results of behaviour therapy in flying phobia. p0088 N74 18782

Assessment of behaviour therapy in the treatment of flying phobia. p0088 N74 18783

## FEEDBACK CONTROL

Design of stability augmentation system for WG13 light rotor helicopter. p0033 N72 11930

Flight test of three axis hydrodynamic stability augmentation system in helicopter. p0034 N72 11937

Application of longitudinal hybrid system and Kalman filter algorithm to feed back control. p0229 N73 20701

C.S.A.S. design for good handling in turbulence. Development of design criteria for static margin factors systems for alleviation of gust effects. p0059 N74 17747

## FIBER ORIENTATION

Application of fiber theory to solidified resins for design and construction of gas turbine engines. p0212 N73 27493

Directional solidification of metal alloys as application to turbine blades and gas turbine engine components. p0213 N73 27494

Fatigue analysis of fiber reinforced composites to determine case using distal energy and maximum strain theories of fatigue. p0213 N73 27500

## FIBER STRENGTH

Design of fibrous composite materials for application to construction of airframes and spacecraft structures. p0210 N73 27479

Tropospheric scattered field strength analysis by synchrotron effect based on transmission. p0118 N71 23455

## FIGHTER AIRCRAFT

Analysis of high subsonic and transonic characteristics of fighter aircraft and factors affecting aerodynamic boundaries for various wing design parameters. p0043 N73 15016

Numerical methods for determining angle of attack of action performance of transport and combat aircraft and effects of various parameters on performance. p0052 N73 24043

Analysis of parameters affecting course of missiles for transport and combat aircraft design purposes. p0055 N73 24048

Development of techniques to measure in flight drag of a US Navy fighter aircraft and correlation of flight measured drag with wind tunnel data. p0022 N74 14734

Design against fatigue. Conference on the fatigue life assessment of tactical aircraft. p0060 N74 19652

Some considerations of the influence of fatigue in the design of strike aircraft. p0060 N74 19653

Fatigue design of strike aircraft. p0060 N74 19654

Structural fatigue analysis and testing for fighter aircraft. p0060 N74 19655

Fatigue and fracture considerations for tactical aircraft. p0062 N74 19656

Fatigue and fracture requirements for tactical fatigue life prediction. p0061 N74 19657

The role of the major fatigue test in the acceptance certification and safe utilization of strike aircraft. p0061 N74 19658

Re assessment of fatigue performance of fighter aircraft. p0061 N74 19659

## FILM COOLING

Performance prediction for turbine blade film cooling with impinging through holes. p0229 N73 20708

Film cooling of gas turbine blades by impinging through holes. p0260 N73 15394

Effect of heat transfer coefficients on cooling systems of gas turbine surfaces. p0260 N73 15395

Technological aspects of film cooling of blades in high temperature gas turbines. p0261 N73 15404

## SUBJECT INDEX

Conference on high temperature turbines detecting effect of film cooling on blade profile loss  
[NASA TM X 67123] p0261 N71 22699

**FILTERS**  
Dual purpose filter separators for dirt and water removal from fuel p0252 N72 11676

**FINITE DIFFERENCE THEORY**  
Finite difference procedure for computing behavior of two-dimensional boundary layers and turbulence model to predict location and extent of transition region p0268 N73 19796  
Numerical treatment of boundary layer problems: finite difference solutions p0185 N74 22918

**FINITE ELEMENT METHOD**  
Finite element computer program for estimating airplane aerodynamic interference  
[NASA TM X 68884] p0003 N71 19357  
Optimization of aerodynamic constraints for aircraft design using differential equation idealization and finite element approximation  
[NASA CR 117198] p0284 N71 20139  
Finite element methods for fluid flow problems p0187 N72 27305  
Calculating eigenfrequencies, modes and generalized masses for a 104G aircraft from drawings by finite element method  
[AGARD R 592] p0293 N72 33915  
Analysis of dynamics of stiffened plates using finite element modeling of flat and curved stiffened panels p0293 N73 29511

**FINNED BODIES**  
Interference flow field of fin flat plate configuration in supersonic turbulent boundary layer channel p0003 N71 19365

**FINS**  
Computer programs for calculating airfoil coefficients of wing horizontal tail and fin horizontal tail oscillated in subsonic flow p0009 N71 29342

**FIRE CONTROL**  
Digital computers for navigation and guidance systems and fire control systems in tactical aircraft p0157 N72 21227

**FIRE EXTINGUISHERS**  
Extinguishing flames and fires on aircraft p0252 N72 11680  
Fire extinguishing system in aircraft using exhaust gases from engine exhaust generator to pressure extinguisher bottle p0251 N72 11685  
Procedure for measuring performance of aircraft fire extinguishing powder p0253 N72 11691  
Use of fluorocarbon fire extinguishers on aircraft fuel lines p0254 N72 11693  
Effects of chemical fire extinguishing agents containing bromotrifluoromethane on cardiovascular and nervous systems of dogs, monkeys, and rats p0077 N73 17106  
[AGARD R 591]

**FIRE PREVENTION**  
Sustained crack tests to assess the resistance of aircraft fuels containing polymeric additives p0254 N72 11692

**FIRES**  
Aircraft fires, fuels, and fire safety considerations  
[AGARD CP 84 711] p0251 N72 11686  
Flammability properties of fuels and techniques for fire and explosion suppression under simulated worst operating environment conditions p0252 N72 11681  
Various gases or emulsified fuels for reducing aircraft crash fire hazard p0253 N72 11689  
The air classification of aircraft fuel tank vapors: a listing of aircraft fuel tank vapor classification and class from fires p0253 N72 11690

**FISHES**  
Burst fish responses to gravitational changes in parabolic flight p0079 N73 21101

**FIXED POINT ARITHMETIC**  
Generation and checkout of computer programs for real time control of aerospace vehicles p0155 N72 21215  
Programming state vectors of future guidance and control computers p0156 N72 21216  
Data word length considerations for aerospace computer implementation to obtain reduced error levels p0156 N72 21217

**FLAMES**  
Laminar flame flames of acetylene-air mixtures p0253 N72 11684

**FLAMMABILITY**  
Discussion of aircraft fuels and techniques to reduce combustion analysis, testing and fire safety  
[AGARD R 44] p0255 N72 27831

**FLAPPING HINGES**  
Analysis of helicopter flap flutter for both rigid and hingeless flap flaps p0052 N73 21970  
[AGARD R 601]

**FLAPS (CONTROL SURFACES)**  
Flap and leading edge flap control for improved aerodynamic control stability of military aircraft p0029 N73 23422  
Transonic wind tunnel determination of Reynolds number effects on flap and leading edge flap aerodynamic pressure distributions and buffet onset p0072 N72 11861  
Design aspects of flap of powered flap aircraft with externally blown flap streamers for performance enhancement in maneuvering conditions: the flap wing p0042 N73 15013

**FLARES**  
Air to ground target acquisition with flare illumination p0303 N73 19968

**FLAT PLATES**  
Turbulent boundary layer measurements on large thermally insulated flat plate at Mach numbers 2.5 to 4.5 p0177 N72 20286  
Effect of quasi-external isotropic turbulence on turbulent boundary layer development on flat plate p0180 N72 20306  
Analysis of surface pressure fluctuations from jet impingement on inclined flat plate with application to design of aircraft with externally blown flaps p0292 N73 29509  
Analysis of structural response to acoustic loading and operation of data sheets for various conditions of acoustic loads p0293 N73 29514

**FLEXIBLE BODIES**  
Passive and semi active attitude control for flexible satellites p0277 N72 12865  
Analysis of aircraft structural flexibility and flight controls interface with application to aircraft design criteria p0039 N72 32031

**FLEXIBLE WINGS**  
Influence of aeroelasticity on flight mechanics of flexible aircraft p0044 N73 16991  
Calculation of induced load effects on controllability of rigid and flexible aircraft p0045 N73 17004

**FOOT CHARACTERISTICS**  
Characteristic flight effects on footache developments in aircraft pilots p0092 N71 22309  
Analysis of aerodynamic, buffeting and related phenomena to include development of models for oscillatory foot injury motion p0043 N73 15018  
Analysis of high subsonic and transonic characteristics of fighter aircraft and factors affecting aerodynamic boundaries for various wing design parameters p0043 N73 15019  
Simulation of flight in Concord to improve characteristics of flight control systems p0046 N73 17013  
Application of computer techniques for determination of three characteristics of aircraft and comparison with model matching data analysis p0046 N73 18030  
[AGARD R 596]  
Helicopter flight performance in takeoff environment p0046 N73 21009  
Flight characteristics and performance of formation type helicopter tail rotor p0046 N73 21078  
Development and application of aircraft performance prediction methods for subsonic and supersonic transport and fighter aircraft p0052 N73 24042  
Numerical methods for determining range and radius of action performance of transport and combat aircraft and effects of various parameters on performance p0052 N73 24043  
Development of methods for predicting aircraft flight maneuvering performance to show effects of excess power and load factor p0053 N73 24045  
Development of computer program for determining minimum time trajectory and comparison with gradient method of optimization p0053 N73 24053  
Flight control and flight transition problems of Dassault Mirage 315 aircraft p0054 N73 27002  
Design development and flight characteristics of VAK 191 B.V. STOJ three motor aircraft p0054 N73 27006  
Review of drag measurement from flight test of manned aircraft with wing devices to wind tunnel tests p0022 N74 14235

**FLIGHT CONDITIONS**  
Influence of environmental factors on aircraft performance and accidents p0070 N71 20369  
Review of a STOJ development program for a transport aircraft consisting of X-142A X-19 and X-22A aircraft under various flight conditions p0054 N73 27001

**FLIGHT CONTROL**  
Loss attitude flight control problems  
[AGARD CP 72] p0061 N74 19516  
Flight simulation and a flight test stand for evaluating operational performance of aircraft flight control system p0022 N73 23420  
In-flight manual control system capability of helicopter flight control display system for helicopters p0011 N72 11929  
Integrated low altitude flight control system for military transport aircraft p0012 N72 11924  
Test aircraft control system for US Army rotary wing aircraft p0012 N72 11927  
Two data link engine data system for engine based performance of low level flight systems p0013 N72 11911  
Design guidelines for primary integrated flight control and guidance systems for V-STOL aircraft  
[NASA CR 126153] p0274 N72 22670  
Computations of induced stability and control due to loss of aircraft control and aileron aircraft reviews p0072 N72 25043  
Application of empirical simulation of instrument flying means of reducing error rates of flight instrumentations in flight p0073 N72 25046  
Display design for guidance and control p0014 N72 25419  
[AGARD R 47]  
Simulation of flight control for improved guidance and flight control systems p0046 N73 17013

## FLIGHT FITNESS

Development of integrated control system for supersonic aircraft based on pneumatic power generation p0066 N73 19056

Measurements of acceleration stress effects on pilot maneuvering ability and flight control performance  
[AMRL TR 72 3] p0106 N73 19154  
Contributions of quality inertial systems to vehicle flight control p0229 N73 20700  
Integrated SAVV, VOR and OME systems for locating and controlling high altitude aircraft p0232 N73 23895  
Flight control and flight transition problems of Dassault Mirage 315 aircraft p0054 N73 27002  
Influence of pilot and aircraft characteristics on structural loads in operational flight: recommendations for improvements in flight instruments to reduce control problems  
[AGARD R 608] p0058 N74 17728  
The effect of gusts and wind shear on automatic STOL approach and landing: simulation and flight test of flight control system for short takeoff aircraft p0058 N74 17730  
Application of energy management concepts to flight path control: turbulence strategy for control of airspeed and flight path with emphasis on landing approach p0069 N74 17744

**FLIGHT CREWS**  
Vibration effects on performance of helicopter flight crews p0068 N71 20355  
Positive effects on flight crew tolerance to positive acceleration p0068 N71 20357  
Application of psychophysiological and psychological factors for treatment of syndromes of readjustment p0069 N71 20365  
Physical fitness of flying personnel and age effects on flight crew performance p0091 N71 22301  
Concomitant system diseases in aging flight crews and removal from flying status p0093 N71 22315  
Statistical study of physiological and psychological factors in grouping of Italian Air Force flight crews p0095 N72 14091  
Clinical causes for permanent poisoning of British aircraft crews p0095 N72 14092  
A review of causes of respiratory and circulatory disorders in Belgian Air Force p0095 N72 14093  
Grouping of flight crew personnel due to naval and aviation duties p0097 N72 14100  
Possible diabetic mellitus in flight crews: Canadian Air Force p0098 N72 14109  
Factors associated with permanent poisoning of some crew members in Royal Air Force p0098 N72 14110  
Design development and testing of sensors for flight crews p0104 N72 15162  
Harboring contamination in the late for late military and physical health of aircrew during flight p0071 N72 24058  
[AGARD AG 151]  
Aeromedical problems and associated techniques for aircrew performance p0073 N72 25048  
[AGARD CP 95 R 2] p0073 N72 25048  
Rarest arterial blood pressure levels in aircrew members p0074 N72 25054  
Respiratory gas analysis for aircrew performance measurements p0074 N72 25057  
[NASA TM X 68370]  
Noise effects on hearing conservation in aircrew and ground support personnel of aircraft operations p0077 N73 17101  
Combined heat, noise and vibration effects on aircrew performance  
[AMRL TR 71 112] p0105 N73 19146  
[AGARD] conference on air to ground target acquisition  
[AGARD CP 100] p0302 N73 19959  
Effects of fueling information on target acquisition performance of observer p0303 N73 19972  
Use of Kati, Respiratory and Techniques for assessing subjective estimates of important parameters for target acquisition p0304 N73 19973  
Physiological aspects of sleep reduction in aircrew after prolonged flight hours p0089 N73 21508  
Spatial characteristics of flight: A basis for a new  
[AGARD AG 170] p0084 N74 12448  
Aircrew response to fatigue: new computer access, memory, and power spectral density methods for fatigue affecting operational performance of crew in the cockpit and environment p0058 N74 17729  
Results of behavioral therapy in flight crews p0088 N74 18192  
Acute and chronic effects of therapy on the treatment of flight crews p0088 N74 18193  
The effects of sleep deprivation on flight crews p0088 N74 18194  
The effects of sleep deprivation on flight crews p0088 N74 18195  
Evaluation of the effects of sleep deprivation on flight crews in ASW operations p0088 N74 18196  
The application of aircrew operational performance tests and equipment to flight safety research p0101 N74 18882

**FLIGHT FITNESS**  
Physical fitness of flying personnel and age effects on flight crew performance p0091 N71 22301  
Concomitant system diseases in aging flight crews and removal from flying status p0093 N71 22315  
Statistical study of physiological and psychological factors in grouping of Italian Air Force flight crews p0095 N72 14091  
Clinical causes for permanent poisoning of British aircraft crews p0095 N72 14092  
A review of causes of respiratory and circulatory disorders in Belgian Air Force p0095 N72 14093  
Grouping of flight crew personnel due to naval and aviation duties p0097 N72 14100  
Possible diabetic mellitus in flight crews: Canadian Air Force p0098 N72 14109  
Factors associated with permanent poisoning of some crew members in Royal Air Force p0098 N72 14110  
Design development and testing of sensors for flight crews p0104 N72 15162  
Harboring contamination in the late for late military and physical health of aircrew during flight p0071 N72 24058  
Aeromedical problems and associated techniques for aircrew performance p0073 N72 25048  
[AGARD CP 95 R 2] p0073 N72 25048  
Rarest arterial blood pressure levels in aircrew members p0074 N72 25054  
Respiratory gas analysis for aircrew performance measurements p0074 N72 25057  
[NASA TM X 68370]  
Noise effects on hearing conservation in aircrew and ground support personnel of aircraft operations p0077 N73 17101  
Combined heat, noise and vibration effects on aircrew performance  
[AMRL TR 71 112] p0105 N73 19146  
[AGARD] conference on air to ground target acquisition  
[AGARD CP 100] p0302 N73 19959  
Effects of fueling information on target acquisition performance of observer p0303 N73 19972  
Use of Kati, Respiratory and Techniques for assessing subjective estimates of important parameters for target acquisition p0304 N73 19973  
Physiological aspects of sleep reduction in aircrew after prolonged flight hours p0089 N73 21508  
Spatial characteristics of flight: A basis for a new  
[AGARD AG 170] p0084 N74 12448  
Aircrew response to fatigue: new computer access, memory, and power spectral density methods for fatigue affecting operational performance of crew in the cockpit and environment p0058 N74 17729  
Results of behavioral therapy in flight crews p0088 N74 18192  
Acute and chronic effects of therapy on the treatment of flight crews p0088 N74 18193  
The effects of sleep deprivation on flight crews p0088 N74 18194  
The effects of sleep deprivation on flight crews p0088 N74 18195  
Evaluation of the effects of sleep deprivation on flight crews in ASW operations p0088 N74 18196  
The application of aircrew operational performance tests and equipment to flight safety research p0101 N74 18882



Clinical causes for permanent grounding of British air fleet crews p0095 N72 14092  
 Analysis of causes of temporary and permanent unfitness in Belgian Air Force p0095 N72 14093  
 Trends and factors related to medical causes for grounding flyers based on USAF School of Aerospace Medicine experience p0096 N72 14095  
 Medical practice management and reasons for grounding in relation to Air Force flying personnel p0096 N72 14096  
 Clinical causes for permanent grounding of German armed forces flying personnel p0096 N72 14097  
 Neuropsychiatric and other causes for permanent grounding of French Air Force flying personnel p0096 N72 14098  
 Ten year analysis of medical factors in flying and flight training in Greek Air Force p0096 N72 14099  
 Circumstances as factor in evaluating flight fitness of Air Force personnel p0096 N72 14101  
 Description of routine cardiological program to determine flight fitness for German Air Force p0097 N72 14102  
 Factors in medical suspensions of Air Force flying personnel p0097 N72 14105  
 Grounding of flight crew personnel due to nasal and aural disorders p0097 N72 14106  
 Nasal and aural disorders and flight fitness in German armed forces p0097 N72 14107  
 Ophthalmological reasons for grounding pilots of German Air Force p0097 N72 14108  
 Psychiatric reasons for permanent grounding of flight crew members in Royal Air Force p0098 N72 14110  
 Psychological factors in pilot grounding in German Air Force p0098 N72 14111  
 Conference on detection, evaluation and identification of drugs and alcohol in flying personnel and effects on flight fitness p0099 N72 21102  
 [AGARD CP 108] p0099 N72 21102  
 Symptomatic in central nervous system affecting flying fitness p0099 N72 23061  
 Pathophysiological conditions compatible with flying [AGARD CP 129] p0098 N72 13784  
 The thousand aviators: Aging and the blood pressure active flying status after age 60 p0084 N74 13786  
 Cardiac valvulopathies and flight lot p0084 N74 13786  
 Asymptomatic aortic insufficiency p0085 N74 13790  
 Asthma in military flying personnel p0085 N74 13792  
 Idiopathic spontaneous pneumothorax in flying personnel p0085 N74 13792  
 A crew's fitness for flying duties after vertebral fractures and spinal surgery p0086 N74 13794  
 The risk of non-patent abnormalities in a crew's Evaluation of ejection cases p0086 N74 13795  
 Aeronautical rehabilitation of flying personnel suffering from acute psychiatric disturbances p0086 N74 13796  
 Importance of the 4-5 sec rhythm in the EEG to determine military flying fitness p0086 N74 13797  
 EEG patterns p0086 N74 13797  
 Ophthalmological supervision of diabetic flying personnel p0086 N74 13798  
 Management of glaucoma in an ageing flying population p0086 N74 13799  
 Current aspects of cochlear function applied to flying personnel p0087 N74 13802  
 Potentials in flying personnel p0087 N74 13802  
 The occurrence of hypotension in flying and confounding subjects of the USAFSAM cardiovascular disease study p0087 N74 13803  
 The problem of diabetes mellitus in aviation medicine: control of hypoglycemic reactions in flying personnel p0087 N74 13804  
 The repeatability of an abnormal 2 hour glucose tolerance test: diagnosis of diabetes mellitus in pilots p0087 N74 13805  
 German Air Force experiences with certain criteria for granting a waiver p0087 N74 13806  
 Influence of social relational factors on operational flying capacity: A system oriented approach p0089 N74 18731

**FLIGHT HAZARDS**  
 Human factors and control system failures in all upsets during turbulence encounters p0029 N71 23414  
 Analysis of spatial disorientation occurrences among military pilots and classification according to types of aircraft and nature of accidents p0071 N72 25033  
 Elevated blood pressure in a crew p0085 N74 13787  
 BOAC experience with turbulence performance requirements for clear air turbulence detecting sensor p0058 N74 17726  
 An airlines experience on turbulence avoidance of atmospheric turbulence through air traffic control meteorological reports and pilot experience p0058 N74 17727  
 The detection of aircraft wake vortices: development of acoustic and wind pressure sensors for vortex detection p0058 N74 17731  
 Wake Vortex Avoidance System program (WVAS) design and implementation of ground based monitoring and predictive system for safety from wake vortices p0058 N74 17732  
 Pilot factor in aircraft accidents of the German Federal Armed Forces p0105 N74 18798  
 Incidence, cost and factor analysis of pilot error accidents in U.S. Army aviation p0107 N74 18804

**FLIGHT INSTRUMENTS**  
 Human perceptual characteristics data relating to individual electronic flight display design p0273 N72 22622

Influence of pilot and aircraft characteristics on structural loads in operational flight: recommendations for improvements in flight instruments to reduce control problems [AGARD R 608] p0058 N74 17728

**FLIGHT LOAD RECORDERS**  
 Design, development and application of flight recorders and crash location instruments used in NATO nations [AGARD AR 39] p0195 N72 32457

**FLIGHT MECHANICS**  
 Engineering analysis on flight mechanics for simulating pilot behavior in aircraft p0172 N71 16062  
 Accident investigations, flight control systems and operational recordings for improved aircraft flight mechanics [AGARD CP 76 71] p0027 N71 23410  
 Operational flight data analysis for improved aviation safety levels p0027 N71 23411  
 Onboard data acquisition for improved aircraft design and operational flight safety p0027 N71 23412  
 Design modifications on short takeoff Brnco aircraft resulting from combat operations tests p0279 N71 23416  
 Landing accidents investigations for Hawker Siddeley 748 aircraft with performance measurements on rough surfaces p0028 N71 23417  
 Safety measures to eliminate aircraft trailing vortex hazards [NASA TM X 67125] p0028 N71 23418  
 Flight mechanics problems in accident investigations for VJ 101 aircraft p0030 N71 23428  
 Stability and control systems for advanced aircraft flight mechanics and safety [AGARD AR 48] p0041 N71 13018  
 Influence of aerelasticity on flight mechanics of flexible aircraft p0044 N71 16991  
 Flight control and flight transition problems of Dassault Mirage 3-55 aircraft p0054 N72 27002

**FLIGHT PATHS**  
 Theory and operation of proposed helicopter IFR flight path control system p0033 N72 11933  
 Probability of acquiring targets by search aircraft which flies along enemy line of communication p0304 N73 19971

**FLIGHT RECORDERS**  
 Onboard data acquisition for improved aircraft design and operational flight safety p0027 N71 23412  
 Design, development and application of flight recorders and crash location instruments used in NATO nations [AGARD AR 39] p0195 N72 32457

**FLIGHT SAFETY**  
 Flight safety performance of V-510L Harrier military aircraft having jet control p0029 N71 23427  
 Helicopter design for improving crash survivability of aircraft and occupants p0101 N72 19141  
 Helicopter flying in poor light and features remain and color vision abnormality p0078 N73 19075  
 Proceedings of conference on air traffic control development and procedures p0232 N73 13689  
 Air traffic control facilities operated by U.S. military forces and developments in improved air traffic control systems p0232 N73 23690  
 Organization and operation of Eurocontrol air traffic control system and development of improved equipment for identification and reporting p0232 N73 23691  
 Characteristics of air traffic control system to include description of electronic components and logic for developing improved equipment p0232 N73 23692  
 Organization, functions, and capabilities of automated air traffic control system for Rome Italy p0232 N73 23694  
 Analysis of North Atlantic en route structure to determine impact of inertial navigation and satellite surveillance on separation reduction p0233 N73 23699  
 Analysis of international air traffic control procedures to determine impact of automation on air traffic controller personnel p0233 N73 23700  
 Development and characteristics of air traffic management system for operation of military and civil under instrument meteorological conditions p0234 N73 23704  
 Development and characteristics of en route landing system with emphasis on terminal design requirements for airborne equipment p0234 N73 23705  
 Development and characteristics of system for separation and control of aircraft to avoid mid-air collisions p0275 N73 23712  
 Analysis of managing high altitude and low altitude ability for air traffic control automation systems p0275 N73 23715  
 Conceptual analysis of improved communication capability and identification system for military applications p0275 N73 23719  
 BOAC experience with turbulence performance requirements for clear air turbulence detecting sensor p0058 N74 17726  
 Experience with a low altitude turbulence model for auto-land certification: correlation of pilot model data with statistical analysis of flight test results p0059 N74 17728  
 The application of air crew operations on cockpit tasks and equipment to flight safety research p0307 N74 18802

**FLIGHT SIMULATION**  
 Human factors in aircraft simulation p0171 N71 16062  
 Dynamic characteristics of a new aircraft simulator for aircraft simulation p0171 N71 16063

Flight simulations for accelerated development of a craft at reduced cost p0171 N71 16062  
 Sensory factors of motion vision and hearing for piloted flight simulation p0171 N71 16064  
 Psychological and environmental factors in selecting pilot simulator tasks p0172 N71 16067  
 Engineering analysis on flight mechanics for simulating pilot behavior in aircraft p0172 N71 16068  
 Human factors in developing a piloted simulation program for evaluating aircraft handling aspects p0172 N71 16069  
 [NASA TM X 65583] p0172 N71 16069  
 Wind tunnel evaluation of lifting body store configurations for captive flight drag and separation characteristics p0066 N71 19386  
 Minimum level of Reynolds number for reliable flow simulation in transonic test facilities p0012 N72 11859  
 [NASA TM X 67412] p0012 N72 11859  
 Feasibility of transonic wind tunnel testing of large cold swept wing panel model for simulating wing shock location at flight Reynolds number p0013 N72 11870  
 [NASA TM X 67414] p0013 N72 11870  
 Measurement accuracy and flow simulation for transonic testing in wind tunnels p0014 N72 11872  
 [NASA TM X 67415] p0014 N72 11872  
 Transonic wind tunnel testing requirements for simulating transonic aerodynamic data at flight Reynolds numbers p0014 N72 11873  
 Equivalent body of revolution for simulating high Reynolds number effect on transonic flow past two dimensional airfoil p0014 N72 11874  
 Wind tunnel model boundary layer reduction through section for accurate simulation of high Reynolds number full scale aircraft characteristics p0014 N72 11875  
 Specifications for high Reynolds number wind tunnel design for flow simulation in swept wing aircraft development tests p0015 N72 11883  
 Advantages of thrust vectoring in manned aircraft combat simulation p0264 N72 16694  
 Application of methods of simulation to instrument flying as means of reducing occurrence of spatial disorientation in flight p0073 N72 25046  
 Application of simulation and analysis techniques for establishing flying qualities criteria for piloted aircraft p0039 N72 32026  
 Measurement of human operator performance in spatial and tracking task during simulated turbulent conditions p0040 N72 32034  
 Fatigue crack propagation under flight simulation loading at 10, 1 and 0.1 cycles per second p0291 N73 16900  
 Summary of conference on flight simulation p0044 N72 16992  
 Role of flight simulation in development of U.S. and F-15 aircraft p0045 N73 17601  
 Simulation of flight in Concord for improving characteristics of flight control system p0046 N73 17012  
 Biased simulator imposing standardized reaction stimuli for selection, test and rehabilitation of motion sick pilots p0079 N73 21098  
 Role of system design and evaluation using a general purpose helicopter flight simulation program p0056 N74 10913  
 Role of simulations in the study and development of the CROTAL system: ground to air close defense weapon system p0237 N74 14355  
 Progress in the mathematical modelling of flight in turbulence: effects of atmospheric turbulence on flying approach and landing of aircraft p0058 N74 17725

**FLIGHT SIMULATORS**  
 Human factors in aircraft simulation p0171 N71 16062  
 [AGARD CP 79 70] p0171 N71 16062  
 Flight simulator mathematical modeling for aircraft design p0171 N71 16063  
 Technical and human engineering requirements for simulating pilot flight p0171 N71 16066  
 High bypass turbofan powered propulsion simulator for engine engine integration analyses at subsonic and supersonic speeds p0003 N71 19369  
 Flight simulator and airframe test stand for evaluating operational performance of aircraft flight control system p0027 N71 23412  
 Developments in aerodynamic test facilities to show past, present status, free flight techniques and future plans [AGARD R 603] p0172 N73 18250  
 Evaluation of helicopter handling qualities based on up and down piloted flight simulator tests p0049 N73 21030

**FLIGHT STABILITY TESTS**  
 Correlation of transonic wind tunnel test data with flight test results of slender wing airplanes for double delta configuration development p0013 N72 11868  
 Transonic wind tunnel testing requirements for simulating transonic aerodynamic data at flight Reynolds numbers p0014 N72 11873

**FLIGHT STRESS**  
 Effects of heavy singular stresses on materials used in constructing side-rear seats p0201 N73 23601

**FLIGHT STRESS (BIOLOGY)**  
 Conflicting human operational flight stress effects on human body and mind p0044 N73 19141  
 [AGARD CP 129] p0044 N73 19141  
 Flight test program to study human factors problems in flight crew performance in military aircraft p0105 N73 19145

## SUBJECT INDEX

Combined heat, noise, and vibration effects on aircrew performance [AMRL TR 71-113] p0105 N73 19148  
Measures to determine psychophysiological reactions of military flight crews to flying stress p0105 N73 19148  
Human stress expenditures in operational flight mission flights p0106 N73 19151  
Influence of long duration flight missions on metabolic and endocrine functions of pilots and navigators p0106 N73 19152  
The occurrence of hypotension in flying and nonflying subjects of the USAFSAK cardiovascular disease study p0087 N74 13803

## FLIGHT SURGEONS

Use of flight surgeon and physician prior in evaluation and treatment of jet fighter pilots p0095 N72 14094  
Operation of and medical cases reviewed by Navy Special Board of Flight Surgeons p0095 N72 14100

## FLIGHT TEST VEHICLES

Proceedings of conference on aircraft flight test procedures data acquisition data processing and correlation with wind tunnel test results [AGARD CP 85] p0034 N72 20976  
Flight test procedures for determining static and spin characteristics of high performance aircraft p0035 N72 20979  
Flight tests to determine buffet characteristics of four high performance aircraft during transonic maneuvers p0043 N73 15017

## FLIGHT TESTS

Flight testing military transport aircraft for handling and performance in STOL applications p0026 N71 20050  
N-126 jet flap research aircraft development and testing p0027 N71 20065  
Accident investigations, flight control systems, and operational recordings for improved aircraft flight characteristics [AGARD CP 76-71] p0027 N71 23413  
Design modifications on short takeoff B-70 aircraft resulting from combat operations test p0028 N71 23416  
Flight test evaluation of military aircraft low altitude high speed performance p0029 N71 23471  
Comparison of wind tunnel and flight data techniques for determining full scale aerodynamic flight data factors [NASA TM X 67413] p0033 N72 11869  
Free flight models for transonic testing at high Reynolds numbers p0034 N72 11878  
[NASA TM X 67416] p0035 N72 11878  
A continuous observation system for SA-330 helicopter and flight test methods p0032 N72 11939  
Flight test of three axis hydraulic stability augmentation system in helicopter p0034 N72 11937  
Complete power plant development emphasizes flight test problems p0035 N72 15705  
Proceedings of conference on aircraft flight test procedures data acquisition data processing and correlation with wind tunnel test results [AGARD CP 85] p0034 N72 20976  
Flight test program and data acquisition techniques for evaluation of Boeing 747 aircraft p0034 N72 20977  
Mathematical models for determining flight performance of transport aircraft p0034 N72 20978  
Stability and control flight test procedures for STOL aircraft in general and specific application to P-1127 and trainer aircraft p0035 N72 20989  
Flight tests of STOL aircraft DO-31 p0035 N72 20989  
Characteristics of flight test methods and techniques for determining stability and sources of error p0035 N72 20984  
Development of flight test procedures for use with advanced aircraft to determine noise performance characteristics p0035 N72 20985  
Test plans and procedures for conducting flight tests of lifting bodies in aircraft design transition and supersonic flight conditions p0035 N72 20986  
[NASA TM X 68106] p0035 N72 20986  
Flight tests performed following of all delivery tests to be repaired and overhaul as performed by Canadian Armed Forces p0036 N72 20987  
Flight test procedures for determining the capability of military aircraft p0036 N72 20989  
Comparison of flight test and wind tunnel data to determine areas of agreement where discrepancies appear in aerodynamic coefficients of aerodynamic aircraft p0036 N72 20990  
Development of commercial process for determining aerodynamic coefficients from flight test data p0036 N72 20991  
Determination of lift performance data with stability and control characteristics of four aircraft p0036 N72 20992  
Organization and operation of the Air Force Test Pilot School p0036 N72 20994  
Procedures for making pilot's assessment of flight systems during attendance at Empire Test Pilot School, England p0036 N72 20995  
Integration of operations and maintenance tests for F-105 at Edwards Air Force Base, California p0037 N72 20996  
Flight test data used in determining the flight performance of aircraft p0037 N72 22744  
Comparison of the flight test and wind tunnel data performance of aircraft with data from wind tunnel high performance aircraft p0038 N72 32018

Procedures for application and revision of Federal Aviation Regulations in determining handling qualities and performance of aircraft p0038 N72 32020

Analysis of criteria for evaluation of high performance aircraft and results obtained on aircraft equipped with control augmentation systems p0039 N72 32025  
Development and application of plotting to determining performance and handling criteria of aircraft p0039 N72 32028

Development of airborne flight data acquisition and data processing systems [AGARD LS 50] p0195 N73 10450  
Design of aircraft flight test instrumentation systems p0195 N73 10451

Selection of dynamic data processing systems p0195 N73 10454  
Analysis of deterministic and random flight data p0195 N73 10455

Procedure for determining noise levels in flight test measuring systems p0195 N73 10456  
Role of theoretical studies of flight dynamics in relation to flight testing p0045 N73 17011

Automatic method for determining stability and control derivatives from flight data p0046 N73 17012  
Flight test program to study human factors problems and flight crew performance in military aircraft p0105 N73 19145

Analysis of procedures and problems involved in operating helicopters from decks of ships p0046 N73 21010  
Improvement in military helicopter flight test techniques to provide data for safety, maintainability, and reliability p0047 N73 21013

Flight tests of XH-51 helicopter to determine effects of gross up and control spring modifications on stability and control p0047 N73 21015  
Discussion of speed record establishment by SA-341 helicopter to provide flight preparation procedures and requirements for successful completion p0047 N73 21018

Flight test procedures for rotary wing aircraft with emphasis on performance and flying patterns p0018 N73 22959  
Flight test and evaluation of CH-84 CH-119 wing V-STOL aircraft with application to specific military roles p0054 N73 22007

Flight tests for determining handling qualities and operational characteristics of Breguet 941 STOL aircraft p0054 N73 22008  
Problems of estimating the drag of a helicopter: correlation of flight test data and scale model test data p0054 N73 22015

Recovery drag measurements from flight tests of rotorcraft aircraft with comparison to wind tunnel predictions p0022 N74 14735

## FLIGHT TIME

Psychological factors in pilots of various aircraft age and flying time and its significance for flight speed performance [AGARD CP 85] p0087 N74 13803

## FLIGHT TRAINING

Medical elimination of students undergoing primary flight training p0073 N72 25049  
Personality traits and flight aptitude p0089 N74 18789  
Flight psychology in student pilots: evaluated by means of Van Dierendonck and Chabert's personality extraction p0089 N74 18790

## FLOW

Drag and separation effects of separated flow in aerodynamic drag p0020 N74 14722

## FLOW CHARACTERISTICS

Flow phenomena and test facilities for transonic speeds [AGARD AR 37-71] p0172 N72 12162  
Nonlinearities in specific determining flow characteristics of supersonic flow test based on layer in aerodynamic gradient p0179 N72 20340

Application of blockage correction to hypersonic wind tunnel test measurements on aircraft models p0042 N73 15006  
Analysis of aerodynamic stability characteristics of wing sections with high lift devices in two dimensional flow p0042 N73 15008

Development of method for analyzing performance of drag reduction devices on aircraft based on theoretical, experimental, and flow characteristics p0065 N73 19357  
Wind tunnel test of military wing section in aerodynamic gradient at several preselected angles of attack and flow area p0049 N73 17037

Aerodynamic characteristics of military wing in transonic flow conditions and development of numerical analysis techniques p0065 N73 19357  
Analysis of numerical techniques for determining aerodynamic characteristics of transonic flow p0065 N73 19357

By aircraft [NASA CP 135473] p0038 N74 13749  
Analysis of drag [AGARD CP 124] p0018 N74 14749  
Aerodynamic drag and lift of general body shapes at various angles of attack and speed p0018 N74 14752

A study of flow separation in the transonic regime and its effects on drag p0022 N74 14749  
Comparison of the flow characteristics of a transonic wing section in the free stream flow p0022 N74 14749

The influence of wave drag on hypersonic entropy wake observations in flow regimes in wake of blunt body viscared by schlieren photography p0022 N74 14733

## FLOW DISTORTION

Flow distortion and performance measurements on 12 in fan in wing mode for range of forward speeds and angle of attack settings in closed wind tunnel p0265 N72 16702

Distortion of grid generated turbulence in stagnation region of two dimensional body p0180 N72 20307

## FLOW DISTRIBUTION

Aerodynamic interference characteristics of airframe propulsion systems of transport and military aircraft [AGARD CP 71-71] p0001 N71 19353

Flight and wind tunnel evaluations of flow field effects on performance of supersonic underwing exhaust nozzles at transonic speeds [NASA TM X 66887] p0003 N71 19366

Wind tunnel surveys of flow fields about wing forebody store configuration inlets of transonic and supersonic aircraft [NASA TM X 66885] p0004 N71 19371

Aerodynamic flow field interference effects on supersonic intakes p0004 N71 19372  
Experimental studies of flow distribution near wall in turbulent boundary layer p0175 N72 20275

Integration of forebody and forebody wing flow fields into airplane design criteria p0031 N72 21018  
Design and performance criteria for high performance supersonic jet systems p0183 N73 12248

Convection equations for a supersonic jet and mixing flow regimes of supersonic jets p0183 N73 12249  
Effects of flow field interference on supersonic jet intake flow patterns p0049 N73 21035

Development of procedure for determining position and strength distribution of shock waves generated by supersonic flow over blunt bodies p0049 N73 21035  
Development of a numerical method for computing flow fields in transonic and supersonic flow p0173 N73 20241

Analysis of the interference of supersonic flow with a transonic flow field caused by mixed supersonic flow p0173 N73 20242  
Aerodynamic interference effects of a jet engine p0073 N73 20242

Flow distortion of supersonic supersonic gas jets interacting with transverse external flow [AGARD CP 76-71] p0087 N74 13803

## FLOW EQUATIONS

Development of procedures for determining planar and curved supersonic flow characteristics [AGARD AG 156] p0076 N72 22007

Development of procedure for determining flow characteristics of high lift systems where viscous effects dominate p0042 N73 15009

## FLOW GEOMETRY

Effects of streamlining variation on turbulent flow applied to boundary layer conditions of wing sections and fuselage fairings [AGARD AG 169] p0184 N73 12042

## FLOW MEASUREMENT

Measurement of flow flow characteristics in a jet to supersonic flow p0042 N73 15009  
Application of laser beam forming to aerodynamic flow fields at supersonic and hypersonic speeds p0194 N72 25420

Development of a method for determining aerodynamic characteristics of a supersonic flow p0194 N72 25420  
Development of a method for determining aerodynamic characteristics of a supersonic flow p0194 N72 25420

Development of a method for determining aerodynamic characteristics of a supersonic flow p0194 N72 25420  
Development of a method for determining aerodynamic characteristics of a supersonic flow p0194 N72 25420

## FLOW RESISTANCE

Comparison of aerodynamic resistance with aerodynamic lift in a transonic flow p0194 N72 25420  
Development of a method for determining aerodynamic characteristics of a supersonic flow p0194 N72 25420

## FLOW STABILITY

Stability of flow field over a blunt body in a supersonic flow p0180 N72 20305

## FLOW THEORY

Development of procedure for determining planar and curved supersonic flow characteristics [AGARD AG 156] p0076 N72 22007

## FLOW VISUALIZATION

Flow visualization techniques and test results in a supersonic flow p0178 N72 20297  
Application of aerodynamic flow visualization techniques to aerodynamic flow fields p0194 N72 25420

Measurement of aerodynamic characteristics of a transonic flow p0194 N72 25420  
Measurement of aerodynamic characteristics of a transonic flow p0194 N72 25420

## FLUCTUATION THEORY

The fluctuation theory of the flow field over a blunt body in a supersonic flow p0178 N72 20297

## FLUID DYNAMICS

- Numerical analysis of one, two, and three dimensional fluid flow conferences  
[AGARD LS 48] p0181 N72 27293
- Evaluation of fluid dynamics of aircraft stalling to determine effects of three dimensional flow wing sweep back and high lift devices  
[AGARD AR 49] p0046 N73 18023
- Fluid motion problems in design and operation of low speed and transonic wind tunnels  
[AGARD R 602] p0183 N73 26279
- Advances in numerical fluid dynamics  
[AGARD LS 64] p0184 N74 22914
- Nonlinear time dependent problems in fluid dynamics  
p0185 N74 22916
- Numerical treatment of fluid dynamical stability problems  
p0185 N74 22921
- FLUID FLOW**
- Harwell heat transfer and fluid flow information analysis center  
p0113 N71 19530
- Design testing and use of heat exchangers in industries and aerospace vehicles conference  
[AGARD LS 57] p0299 N72 18946
- Development and characteristics of laser Doppler velocity instrument to measure velocities of flowing fluids  
p0200 N72 25505
- Numerical analysis of Navier Stokes equations for time dependent nonlinear fluid flow  
p0181 N72 27299
- Finite element methods for fluid flow problems  
p0182 N72 27305
- FLUID JETS**
- Angular momentum exchange systems jet ejection on systems and magnetic torquers for active satellite attitude control  
p0277 N72 12866
- FLUID MECHANICS**
- Mathematical aspects of fluid mechanics and numerical analysis of partial differential equations  
p0181 N72 27294
- MATHEMATICAL MODEL FOR FLUID MECHANICS**  
p0182 N72 27308
- FLUORESCENCE**
- Sequential spark electron beam fluorescence probe and electrostatic probe array methods for measuring turbulent wake properties in hypersonic spheres p0178 N72 20296
- FLUOROCARBONS**
- Effects of positive G<sub>y</sub> acceleration on blood oxygen saturation and pleural pressure relations in dogs breathing air and liquid fluorocarbons in whole body water immersors on respirator  
[NASA CR 117199] p0066 N71 20358
- Effects of chemical fire extinguishing agents containing bromotrifluoromethane on cardiovascular and nervous systems of dogs, monkeys, and baboons  
[AGARD R 599] p0077 N73 17106
- FLUTTER**
- Application of active controls to suppression of flutter for supersonic aircraft  
p0045 N73 17005
- Application of a general method for flutter optimization  
p0297 N74 15609
- FLUTTER ANALYSIS**
- Aeroelastic and flutter analysis for T-tail of Fokker F-28  
p0009 N71 29344
- Method for calculating flutter using interference aerodynamic forces between wing and tail  
p0009 N71 29345
- Analysis of helicopter blade flutter for both hinged and hingeless rotor blades  
[AGARD R 607] p0052 N73 21920
- Effect of surface pressure fluctuations on response of panels underlying attached and separated turbulent boundary layers and shock waves  
p0292 N73 29910
- Comments on NASA Langley research on transonic unsteady aerodynamics flutter calculation methods  
[NASA TM X 69997] p0023 N74 18652
- FLY BY WIRE CONTROL**
- Artificial stabilization to correct control deficiencies for high performance aircraft  
p0045 N73 17009
- FLYING PERSONNEL**
- Physiological test program to evaluate physical fitness of flying personnel  
p0091 N71 22302
- Diagnostic and functional measurements of human physical fitness  
p0091 N71 22303
- Physical fitness training schedules for Canadian Forces flying personnel  
p0091 N71 22305
- Physical exercise and fitness tests for German Air Force flying personnel  
p0091 N71 22307
- Physical exercise and environmental emotional/psychological therapeutic methods in aerospace medicine  
p0092 N71 22310
- Aging effects on military flight crew body composition and physical exercise performance  
p0093 N71 22316
- Cardiovascular disease effects in aging flying personnel on physical exercise performance  
p0093 N71 22317
- Formula for predicting physical fitness of flying personnel in Belgian Air Force during aging process from spontaneous measurements  
p0094 N71 22321
- Trends and factors related to medical causes for grounding flyers based on USAF School of Aerospace Medicine experience  
p0096 N72 14095
- Medical practice management and research for grounding in relation to Air Force flying personnel  
p0096 N72 14096
- Clinical causes for permanent grounding of German military forces flying personnel  
p0096 N72 14097
- Neuropsychiatric and other causes for permanent grounding of French Air Force flying personnel  
p0096 N72 14098
- Cardiac conditions as factor in evaluating flight fitness of Air Force personnel  
p0096 N72 14101
- Factors in medical suspensions of Air Force flying personnel  
p0097 N72 14105
- Psychopathology among French Air Force flying personnel  
p0098 N72 14112
- French school for training navigation personnel  
p0036 N72 20993
- Development of procedures for exposing aviators to effects of spatial disorientation in ground based simulator  
p0073 N72 25045
- Clinical evaluation and medical treatment of spatial disorientation problems in flying personnel  
p0073 N72 25047
- One channel portable tape recording system for long term ECG recording of flying personnel  
p0073 N72 25051
- Aptitude for recovery from vertigo in flying personnel  
p0074 N72 25059
- Color vision requirements for flying personnel of various armed forces conferences  
[AGARD CP 99] p0077 N73 19065
- Color vision testing and selection procedures for flying personnel since World War I  
p0077 N73 19069
- Color vision tests as predictive indicators of flying task performance  
p0078 N73 19074
- Color vision requirements for air crew personnel of future including coding evaluation  
[AMRL TR 71 116] p0078 N73 19076
- Conference on detection, evaluation, and identification of drugs and alcohol in flying personnel and effects on flight fitness  
[AGARD CP 108] p0079 N73 21102
- Drug therapy effects on flying effectiveness and psychomotor fitness of flying personnel  
p0080 N73 21103
- Drug screening data for civil aviation personnel obtained by urinalyses  
p0080 N73 21104
- Chemotherapy for air crews in Great Britain  
p0080 N73 21105
- Suitability of insulin dependent and oral drug dependent diabetics as navigation personnel  
p0082 N73 21120
- Ophthalmological examination of antimalarial drugs effects on performance of navigation personnel  
p0082 N73 21122
- Flight safety factors in prescribing tranquilizing drugs for flying personnel  
p0082 N73 21123
- Pathophysiological conditions compatible with flying  
[AGARD CP 128] p0084 N74 13784
- Technical evaluation report conclusion and recommendations pathophysiological standards for flying personnel certification  
p0084 N74 13785
- Elevated blood pressure in aircrew  
p0085 N74 13787
- Value of cardiac mechanograms in evaluating flying personnel  
p0085 N74 13791
- Idiopathic spontaneous pneumothorax in flying personnel  
p0085 N74 13793
- Aircrew's fitness for flying duties after vertebral fractures and spinal surgery  
p0086 N74 13794
- The risk of minor spinal abnormalities in aircrews  
p0086 N74 13795
- Evaluation of ejection cases  
p0086 N74 13796
- Aeronautical rehabilitation of flying personnel suffering from acute psychiatric disturbances  
p0086 N74 13796
- Importance of the 4-5 c/sec rhythm in the EEG to determine military flying fitness  
p0086 N74 13797
- Ophthalmological supervision of diabetic flying personnel  
p0086 N74 13798
- Management of glaucoma in an aging flying population  
p0086 N74 13799
- Current aspects of cochlear function applied to flying personnel  
p0086 N74 13800
- Proteinuria in flying personnel  
p0087 N74 13802
- The occurrence of hyperlipidemia in flying and nonflying subjects of the USAFSAM cardiovascular disease study  
p0087 N74 13803
- The problem of diabetes mellitus in aviation medicine control of hypoglycemic reactions in flying personnel  
p0087 N74 13804
- The repeatability of an abnormal 2 hour glucose tolerance test diagnosis of diabetes mellitus in pilots  
p0087 N74 13805
- German Air Force experiences with certain criteria for granting a waiver  
p0087 N74 13806
- Interest of nystagmography in flying navigation personnel  
p0108 N74 20738
- Manual of aeronautical medicine and application to navigation personnel  
p0089 N74 27227
- FLYWHEELS**
- Design development and application of electrically driven flywheels for stabilization of synchronous satellites  
p0192 N72 19493
- FOG**
- Simulation of pilot decision making process in manual landing operation during fog  
p0280 N73 23898
- FOOD INTAKE**
- Metabolic imbalances and body hypohydration during food deprivation for 10 days  
p0070 N71 20358
- FORCE DISTRIBUTION**
- Specialists Meeting on Helicopter Rotor Prediction Methods  
[AGARD CP 127] p0055 N74 10998
- Rotary wing design methodology based on nonlinear aeroelastic blade loads analysis  
p0056 N74 10909
- The prediction of loading actions on high speed semi-rigid helicopters  
p0056 N74 10914
- Integrated rotor/body loads prediction  
p0057 N74 10918
- FORCED CONVECTION**
- Heat exchangers and forced convection liquid metal heat transfer  
p0299 N72 18948
- FOREBODIES**
- Forebody and forebody wing configuration data for supersonic inlet performance and distortion during maneuvering flight  
p0286 N72 16710
- FORGING**
- Stress corrosion behavior of die forgings made from Al-Zn-Mg-Cu alloys  
p0288 N72 21922
- Improvement of the properties of high strength Al-Zn-Mg-Cu alloys by thermomechanical procedures ductility, toughness and stress corrosion properties of steel plates and forgings  
p0204 N74 23111
- FORMING TECHNIQUES**
- Fabrication of cobalt alloy and nickel alloy gas turbine blades and disks  
p0259 N71 17392
- FORTAN**
- Computer programs for analyzing optical properties of sea water  
p0243 N73 33838
- FORWARD SCATTERING**
- Forward and backscattering caused by wave interaction with auroral ionization and theories of irregularity production  
p0126 N72 2112A
- Measurement of light scattering at various angles using point spread function and modulation transformation function techniques  
p0242 N73 33629
- FOURIER TRANSFORMATION**
- Fast Fourier transform digital processor as spectrum analyzer and adaptive filter  
p0132 N73 10198
- FOVEA**
- Application of extra foveal vision to predicting target acquisition in air to ground search  
p0132 N73 19960
- FRACTOGRAPHY**
- Techniques applications and scope of fractography  
[AGARD AG 155 71] p0285 N72 13882
- FRACTURE MECHANICS**
- Mechanical properties of fiber reinforced materials  
p0206 N71 27043
- Application of linear elastic fracture mechanics to developing stress corrosion cracking test standards  
[NASA TM X 68303] p0286 N72 21905
- Determination of stress corrosion cracking parameters for 300M steel  
p0286 N72 21906
- Stress corrosion index for measuring conjoint action between stress and corrosion in stress corrosion of Al alloys  
p0286 N72 21908
- Ultrahigh vacuum for determining effects of hydrogen on fatigue and fracture properties of Ni-200  
p0287 N72 21916
- Metallurgical aspects of fatigue and fracture toughness conference on effects of microstructure on mechanical properties of airframe materials  
[AGARD R 610] p0204 N74 23108
- FRACTURE STRENGTH**
- The metallurgical aspects of fatigue and fracture toughness effects of microstructure on mechanical properties of airframes and construction materials  
p0204 N74 23109
- Some recent developments in fatigue and fracture microstructural origins of fracture resistance of high strength steels  
p0204 N74 23110
- FRACTURING**
- Causes of compression fractures and resorption of duties by Greek pilots after recovery  
p0102 N72 19149
- Aircrew's fitness for flying duties after vertebral fractures and spinal surgery  
p0086 N74 13794
- The risk of minor spinal abnormalities in aircrews  
p0086 N74 13795
- Evaluation of ejection cases  
p0086 N74 13795
- FRANCE**
- Research equipment methods and facilities at Propulsion Test Center, France  
p0263 N72 16890
- French school for training navigation personnel  
p0036 N72 20993
- Color aptitude of dyschromatopsia French navigators and pilots  
p0077 N73 19068
- FREE FALL**
- Exposure to extreme forces through human accidental and suicidal free falls  
p0099 N72 19125
- FREE FLIGHT**
- Free flight models for transonic testing at high Reynolds numbers  
p0015 N72 11878
- Role of free flight models in aircraft research and development  
p0045 N73 17007
- FREE FLOW**
- Approximation of two dimensional turbulent boundary layer under arbitrary wall and free flow conditions  
p0176 N72 20272
- Effect of free stream turbulence level on turbulent boundary layer behavior  
p0268 N73 19799
- FREE JETS**
- Free jet tests of full scale supersonic intake engine combination of Centrite power plant  
p0285 N72 15704
- FREE SATELLITES**
- Passive gravity gradient method for stabilization of free and pole satellites  
p0278 N72 12867

## SUBJECT INDEX

### FREON

Aerodynamic suitability of Freon 12 for wind tunnel testing of transport aircraft models at increased Reynolds numbers and supersonic and supercritical Mach numbers [NASA TM X 67417] p0015 N72 11879

### FREQUENCY ASSIGNMENT

The identification of military utilization of frequency bands above 10 GHz [AGARD AR 42] p0149 X74 73498

The identification of military utilization of frequency bands above 10 GHz [AGARD AR 42 REV] p0149 X74 73499

### FREQUENCY COMPRESSION DEMODULATORS

Signal to noise ratio performance of optimum digitalized FM demodulator p0131 N73 10195

### FREQUENCY CONTROL

Mathematical model for frequency correlation function of tropospheric scatter channel p0119 N71 23464

Frequency correlation measurements on multipath tropospheric scatter propagation p0119 N71 23465

Economic analysis of integrated time frequency system for aircraft p0235 N73 23717

### FREQUENCY DISTRIBUTION

Cumulative frequency distributions determined by extreme value analysis used for fatigue analysis and interpretation of g vertical acceleration and gust velocity measured on transport aircraft [AGARD R 579 71] p0030 N71 75080

### FREQUENCY MEASUREMENT

Power spectral densities, Doppler shifts, and phase fluctuations of frequency distribution in aerial HF propagation p0129 N72 21143

### FREQUENCY RESPONSE

Power spectrum method for determining gust frequency response functions in dynamic aircraft design p0007 N71 23211

Impulse response measurements and radio test link for evaluating tropospheric scatter propagation channel capacity p0119 N71 23466

### FRETTING

Effects of fretting on fatigue of materials and development of anti fretting compounds and metal working procedures to reduce fretting [AGARD AR 45] p0290 N72 29922

### FRICTION FACTOR

Compa heat exchangers with large amounts of heat transfer area per volume unit and heat transfer fluid flow power relation p0299 N72 18947

### FROGS

Cardiac and neural effects of ultrafast energy storage p0068 N71 20354

### FUEL COMBUSTION

Corrosion resistant materials for nozzle guide vanes and turbine blades subject to vanishingly small fuel combustion p0203 N73 23613

### FUEL CONSUMPTION

Numerical analysis of minimum time climb procedure and minimum fuel climb procedure for typical subsonic aircraft p0053 N73 24552

### FULL FLOW

Main methods of fuel flow measurement and factors for consideration of secondary flow type of meter use for various requirements [AGARDOGRAPH 160 VOL 3] p0194 N72 25420

### FUEL SYSTEMS

Aviation fueling facilities and fueling operation p0252 N72 11678

### FUEL TANKS

Electrostatic charging in handling of aviation fuels resulting in incendiary sparking in fuel tanks p0253 N72 11686

Fire and explosion protection fuel tank stages including oxygen reduction vapor or mist inerting and plastic foam filters p0253 N72 11689

### FUEL TESTS

Properties evaluation of lubricants and fuels for use in advanced aircraft gas turbine [NASA CR 122842] p0254 N72 11694

### FULL SCALE TESTS

Correlation between full scale fatigue test facilities and actual service facilities for general aviation aircraft p0291 N73 16991

### FUSELAGES

Three dimensional aerodynamic half scale pressure fields and effects on stakes mounted adjacent to aircraft fuselage p0033 N71 19167

Optimization and design of the rear wing of the A 300 B aircraft structure p0298 N74 15614

C

### GAS ANALYSIS

Application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustor chambers [AGARD R 168] p0111 N73 13130

Gas sampling and analysis in combustion phenomena [AGARDGRAPH 166 FR] p0111 N74 22799

### GAS BAGS

Safety belts and air bags for highway accident protection p0699 N72 19126

Air bag and seat belt analysis as restraint systems for European car collisions p0699 N72 19129

### GAS BEARINGS

Development of spherical hydrostatic compliant bearing for directional gyroscopes p0229 N73 20695

### GAS DYNAMICS

Numerical analysis of time dependent gas dynamics and accuracy in regions of continuous flow p0192 N72 27304

### GAS FLOW

Turbulent mixing layer between two different gas streams such as nitrogen and helium p0178 N72 20291

Numerical analysis of viscous gas flow and shock formation p0181 N72 27300

Numerical analysis of three dimensional ideal gas flow and Euler equations of motion p0182 N72 27307

Physical structure of turbulent shear flows in nonreacting gas flow [AGARD AR 46] p0182 N73 11262

### GAS GENERATORS

Development of techniques for evaluating performance of air breathing engines and measurement of significant operating parameters [NASA TM X 68305] p0035 N72 20983

### GAS INJECTION

Mathematical models for calculating turbulent boundary layer injected with gas p0180 N72 20307

### GAS MIXTURES

Adiabatic compression method for determining self ignition delay in hydrocarbon air fuel mixtures p0272 N72 11682

### GAS TURBINE ENGINES

Advanced cooling systems and heat resistant materials for turbine blades of high temperature aeronautical gas turbine engines [AGARD CP 73 71] p0257 N71 17372

High entrance temperatures for improved performance of turbogenerators and gas turbine engines p0257 N71 17373

Mathematical model for calculating blade temperatures in convective cooled gas turbines p0257 N71 17375

Heat transfer and heat flux measuring sensors for gas turbine engines p0257 N71 17377

Design and component testing of cooled radial gas turbine engine p0258 N71 17381

Aerodynamic and thermodynamic performance of sweat cooled gas turbine engine blades p0258 N71 17382

Heat transfer in air cooling and sweat cooling techniques for high temperature gas turbine engine components p0258 N71 17383

Transpiration cooled blades for high temperature inlet gas turbine engines p0258 N71 17384

Design of gas turbine engines for high operating temperatures p0258 N71 17386

Temperature field measurements within convection cooled radial blade of gas turbine engine p0259 N71 17387

Cobalt and nickel based alloy metallurgy for high temperature gas turbine materials p0259 N71 17389

Thermal control coatings for refractory gas turbine materials p0259 N71 17391

Performance of alumina coatings in simulated high temperature tests of gas turbine engine parts [NASA CR 116374] p0259 N71 17393

From cooling of gas turbine blades by an injection cooling tube p0260 N71 17394

Effective heat transfer coefficient in film cooling systems of gas turbine combustors p0260 N71 17395

Air cooling systems for nozzle guide vanes of aircraft gas turbines p0260 N71 17396

Operational design criteria for gas turbine engines p0261 N71 17402

Production and efficiency of small gas turbine engine for helicopter and surface vehicles [AGARD LS 46 71] p0261 N71 26951

Cost effectiveness as critical selection requirement for small gas turbines in military and commercial operations p0262 N71 26952

Design and performance of gas turbine engines for helicopters and surface transport vehicles p0262 N71 26953

Components for low weight small volume aircraft gas turbine engines p0262 N71 26955

Engineering aspects and manufacturing of gas turbine engines for helicopters and ground transport vehicles p0262 N71 26956

Components and design of small aircraft gas turbine power plants for aircraft and ground vehicle propulsion p0262 N71 26958

Analysis of lubricant system used in oil cooled gas turbine engine p0274 N72 11697

Analysis of gas turbine engine requirements and performance when an propulsion system for a vehicle has power plant p0085 N73 19059

Performance of aircraft gas turbine components in hot foreign environments p0201 N73 23599

Chemical and thermal stability of aircraft gas turbine engine components p0201 N73 23600

Analysis and synthesis of glass reinforced materials in aircraft and missile structure composition and application to gas turbine engines p0210 N73 27476

Application of reinforced composite materials for construction of aeronautical gas turbine engines p0212 N73 27499

Directional suitability of fiber reinforced plastic and carbon fiber blades and gas turbine engine components p0213 N73 27494

## GLASS FIBERS

Parameters controlling nitric oxide emissions from gas turbine combustors p0219 N74 14291

Factors controlling pollutant emissions from gas turbine engines p0230 N74 14292

Development and validation of an analytical model for predicting emissions from gas turbine engine combustors during low power operation p0220 N74 14295

Motorist point of view on the effects of low burning rates on pollution p0221 N74 14303

### GAS TURBINES

Conference on high temperature turbine detailing effect of film cooling on blade profile loss [NASA TM X 67123] p0261 N71 26999

Cost effectiveness as critical selection requirement for small gas turbines in military and commercial operations p0262 N71 26952

Thermodynamic cycle and power output parameters of gas turbine p0262 N71 26954

The thermodynamic properties of small gas turbines for power generation in aeronautics space and industry p0262 N71 26957

Properties evaluation of lubricants and fuels for use in advanced aircraft gas turbine [NASA CR 122842] p0254 N72 11694

Assessment of high temperature stability of various lubricants for aircraft gas turbines p0254 N72 11695

Asymmetric inlet flow and cavitation theories for small gas turbines p0265 N72 16701

Sulfur, sodium, and chloride contamination in gas turbines p0202 N73 23610

Methods of oxidation and corrosion resistance in the turbine metal alloys used in gas turbine engines p0203 N73 23617

Prediction of transfer and thermal properties of materials from direct radiative calculation of molecular absorption and emission for gas turbine blades and vanes p0272 N72 27492

Application of glass fiber reinforced plastic for turbine engine components in operation in high temperature environments p0213 N73 27493

Application of boron atomized impingement cooling for construction of turbine blades with low thermal conductivity in high cycle fatigue p0213 N73 27497

An experimental research on the behavior of a turbine in low thrust on chamber p0220 N74 14296

Smoke suppressant additive effects on particulate emissions from gas turbine combustors p0221 N74 14299

A preliminary study of the influence of fuel type on nitric oxide emissions from gas turbine combustors p0221 N74 14301

Aircraft gas turbine propulsion thrusts as a function of forward momentum effect on engine performance p0221 N74 14304

### GAS METAL INTERACTIONS

High temperature environmental testing of gas metal interactions to simulate severe operating conditions p0202 N73 23606

### GAS SOLID INTERFACES

Critical review and rounded table discussion data for colloidal reactions between gases and solids [AGARD AR 32 71] p0251 N73 19177

### GALLED PROPELLANTS

Crash safe turbine fuel program using galled fuel p0253 N72 11687

Various galling on emulsified fuels for reducing aircraft crash fire hazard p0253 N72 11689

Research and development program for military geodetic photogrammetry using a theodolite technique in photogrammetric data p0211 N73 27486

### GEOMORPHOLOGY

Variable coefficient in parabolic equations of flow for analyzing geomorphologic media through magnetic resonance spectra p0125 N72 16116

### GERIATRICS

Diagnostic ultrasonical and physiotherapy criteria in geriatrics p0092 N71 22317

### GERMANY

Cooperation agreements for German A 1 engine power p0017 N73 19367

German cooperation in international aircraft engine design p0004 N73 26959

### GIMBALLESS INERTIAL NAVIGATION

Computerized inertial guidance system for aircraft flight control p0280 N73 27895

### GLASS

Electrical resistance measurement for determining stress strain behavior of glass fiber reinforced plastic in a reduced plastic material exposed to water p0208 N72 12505

### GLASS FIBERS

Analysis of tests for glass stress response in matrix and fiber by theory in glass epoxy resin composites p0207 N72 12509

Application of glass composites in aircraft engine parts and PPR 49 organic fiber materials for helicopter and space craft construction p0211 N73 27486

Application of glass reinforced plastic in aircraft and composite materials for helicopter structures and airframe wings p0211 N73 27493

Construction of ultra high strength glass fiber and carbon fiber reinforced plastic composite materials for aircraft reduction and weight saving p0211 N73 27486

Application of glass and carbon fiber reinforced structures for gas turbine engine components to operate in high temperature environments p0213 N73 27495

**GLAUCOMA**

Management of glaucoma in an ageing flying population p0086 N74 13799

**GLIDERS**

Construction of glider aircraft using glass fiber and carbon fiber reinforced plastic composite materials for weight reduction and increased strength p0211 N73 27486

**GLUCOSE**

The repeatability of an abnormal 2 hour glucose tolerance test diagnosis of diabetes mellitus in pilots p0087 N74 13805

**GRAPHITE**

Oilatometric thermal expansion measurements on high temperature structural materials [AGARD AR 31 71] p0199 N71 25358

Thermal expansion behavior of platinum, Al2O3, tungsten alloys and graphite p0299 N72 24980

Physical and mechanical properties of high strength high modulus reinforcing fibers and organic resin composite materials p0210 N73 27475

**GRAPHS (CHARTS)**

Intuitive graphical and simplified mathematical treatment of rotational dynamics as applied to human centrifuges p0094 N71 23340

Tabular and graphical summary of human tolerances to prolonged acceleration stresses p0094 N71 23341

Computer aided input of graphic information on chemical structures by keyboarding under visual control of display device p0157 N72 22170

**GRAVITATIONAL EFFECTS**

Spatial distortion in flight A handbook for aircrew [AGARD AG 170] p0084 N74 12748

**GRAVITATIONAL WAVES**

Conference on acoustic gravity wave effects in atmospheric transmission of radio communication signals [AGARD CP 115] p0134 N73 14131

Comparison of ionospheric radio wave propagation and acoustic gravity wave propagation p0134 N73 14132

Effects of acoustic gravity wave diffusion on atmospheric boundaries p0135 N73 14136

Acoustic gravity wave generation by transient sources in isothermal atmosphere p0135 N73 14139

Nuclear source model for generating ionospheric disturbances through acoustic gravity waves p0135 N73 14141

Asymptotic methods for determining propagation angles of internal gravity waves traveling at ionospheric heights p0136 N73 14144

Full wave solution for electron density perturbations caused by gravity waves in F2 region p0136 N73 14145

Relationship between atmospheric gravity waves and spread F conditions caused by solar activity p0136 N73 14146

Ionospheric gravity wave electron amplitudes and spectra p0137 N73 14149

Detection of tropospheric turbulence and gravitational waves by radar sounding p0137 N73 14151

Microwave radar detection and photography of gravitational waves in troposphere p0137 N73 14152

Electromagnetic cross modulation and very low frequency propagation techniques for measuring acoustic gravity waves in ionospheric D region p0137 N73 14153

Radar observations of meteor trains for detecting high altitude gravity waves p0137 N73 14155

High frequency radar backscattering technique for determining ionospheric structure and gravity wave disturbances p0137 N73 14155

Gravity wave effects in occurrence time changes of daily traveling ionospheric disturbances p0138 N73 14156

Theoretical plasma perturbation model for calculating coupling effects between acoustic gravity waves and electromagnetic waves in ionospheric disturbances p0138 N73 14162

Computerized simulation of gravity wave perturbed traveling ionospheric disturbances using radio ray paths p0139 N73 14163

Atmospheric gravity wave effects on ionospheric trans-equatorial radio wave propagation in presence of traveling ionospheric disturbances p0139 N73 14164

Acoustic gravity wave effects in traveling ionospheric disturbances following nuclear explosions p0139 N73 14166

Nonlinear propagation and ionospheric coupling of atmospheric waves following nuclear explosions p0140 N73 14168

**GREAT BRITAIN**

Procedures for training pilots in assessment of flight systems during attendance at Empire Test Pilot School, England p0036 N72 20995

Cooperation requirements of Great Britain's Armed Forces p0077 N73 19072

Cremotherapy for air crews in Great Britain p0080 N73 21105

**GREECE**

AGARD Annual Meeting, 1973 Conference on research and development in Greece and use of science and technology to meet military requirements at reduced costs p0394 N74 21610

Research and development activities in Greece p0305 N74 21611

Electronics and space activities in Greece wave propagation and electron density research p0305 N74 21612

**GROUND BASED CONTROL**

Measurement methods and error analyses by ground terminals for optimizing satellite communications link p0133 N73 10203

**GROUND CREWS**

Noise effects on hearing conservation in aircrew and ground support personnel of aerospace operations p0077 N73 17101

Drug screening data for civil aviation personnel trained by unanalysed p0080 N73 21104

**GROUND EFFECT**

Development of method for calculating near field noise level of free jet and influence of ground effect on noise produced by V-STOL aircraft operation p0252 N73 29907

**GROUND EFFECT MACHINES**

Minimum weight design of surface effect vehicle using the sieve search technique p0297 N74 15810

**GROUND SPEED**

Possible use and limitations of rotary and fixed wing compatible Doppler sensor designs p0031 N72 11923

**GROUND STATIONS**

Multi-station observations November 1971 March 1972 p0187 N74 14087

**GROUND SUPPORT EQUIPMENT**

Development of integrated system for performing checkout of space launchers and aircraft systems p0191 N72 19489

Pollution control of airport engine test facilities p0219 N74 14285

**GROUND TESTS**

High Reynolds number aerodynamic ground testing by moving test specimens on rocket sleds p0016 N72 11885

Characteristics of air traffic control system to include description of electronic components and projects for developing improved equipment p0232 N73 23692

Status and trends of civil air traffic control systems and development of automated network for increased flight safety p0233 N73 23696

**GUIDANCE (MOTION)**

Display design for guidance and control [AGARD AR 43] p0194 N72 25419

**GUIDANCE SENSORS**

Application of guidance laws to control and guidance of tactical missiles to reduce amount of miss distance p0227 N72 27689

Characteristics of command to line of sight guidance and semi active homing missile systems applied to guidance and control of tactical missiles p0227 N72 27692

Testing of an attitude control unit for sounding rockets p0236 N74 14349

**GUIDE VANES**

Air cooling systems for nozzle guide vanes of aircraft gas turbines p0280 N71 17396

Corrosion resistant materials for nozzle guide vanes and turbine blades subject to vanadium containing fuel combustion p0203 N73 23613

**GUST ALLEVIATORS**

CASA design for good handling in turbulence development of design criteria for stability augmentation systems for alleviation of gust effects p0050 N74 17741

A new approach to gust alleviation of a flexible aircraft using an open loop device application to control system of SE 210 aircraft p0060 N74 17745

**GUST LOADS**

Cumulative frequency distributions determined by extreme value analysis used for fatigue analysis and interpretation of g.c. vertical acceleration and gust velocity measured on transport aircraft p0030 N71 25080

Collection and processing of gust load data obtained from counting accelerometers mounted at center of gravity of various aircraft p0046 N73 20023

Flight in turbulence proceedings of conference on atmospheric turbulence and effects on aircraft operation [AGARD CP 140] p0057 N74 17116

Structural loads and gust criteria comparison of gust load analysis methods for application to aircraft design p0059 N74 17739

A new approach to gust alleviation of a flexible aircraft using an open loop device application to control system of SE 210 aircraft p0060 N74 17745

**GUSTS**

Power spectrum method for determining gust frequency response functions in dynamic aircraft design p0007 N71 23211

**GYROSCOPES**

Gyroscope theory and applications to inertial guidance and navigation vehicle stabilization and related uses bibliography [AGARD R 582 71] p0189 N71 20002

Development of single degree of freedom gyroscope for application to strapdown inertial guidance system p0228 N73 20688

Method for testing and acceptance tests and reliability tests of gyroscopes as part of inertial platform quality control procedures p0228 N73 20689

Development of special hydraulic compensated feedback for free gyroscopes p0229 N73 20695

Mathematical models for measuring operating functions and performance of gyroscope with two degrees of freedom p0229 N73 20696

Dynamically tuned gyros in strapdown systems p0229 N73 20697

Parameters of single axis floated gyroscopes when used in inertial systems requiring rapid gyrocompassing for alignment p0231 N73 20703

**GYROSCOPIC STABILITY**

Three axis gyro stabilized torpedo platform p0230 N73 20702

**H****H 126 AIRCRAFT**

H 126 jet flap research aircraft development and testing p0027 N71 20086

**HABITUATION (LEARNING)**

A proposed habituation labyrinth (Presentation of several results with the P.N.I.) p0108 N74 20737

**HALF CONES**

Lift and drag interference characteristics of delta winged half cones with leading edges p0002 N71 19359

Three dimensional interactions in half cone pressure fields and effects on intakes mounted adjacent to aircraft fuselage p0003 N71 19367

Ties of half cone angles for Mach numbers 3 to 20 [AL JRDGRAPH 137 PT 3] p0175 N72 15289

**HANDBOOKS**

Handbook on aviation medicine for safe mental and physical health of aircrew during flight [AGARD AG 154] p0071 N72 24058

Spatial distortion in flight A handbook for aircrew [AGARD AG 170] p0084 N74 12748

Manual of aeronautical medicine and application to navigation personnel [AGARDGRAPH 1541FRI] p0089 N74 22727

AGARD handbook (including AGARD by laws) p0306 N74 23497

**HARMONIC MOTION**

Influence of various aerodynamic forces on rectangular wing performance with harmonic movement parallel to sieve flow movement p0050 N73 21043

**HARMONIC OSCILLATION**

Numerical analysis of aerodynamic loads and coefficients for tandem and T tail surfaces harmonically oscillating in subsonic flow p0007 N71 29335

Calculation of pressure distributions over wings with harmonic oscillating control surfaces using kernel function method p0009 N71 29346

Unsteady pressure measurements on harmonically oscillating swept wing with two control surfaces in incompressible flow p0010 N71 29350

**HARNESSES**

Acceleration protection system design in pack testing of restraint harnesses and ejection seat cushions and implications p0104 N72 19157

**HARRIER AIRCRAFT**

Harrier aircraft navigation display and computer unit with projected moving map means of storing and selecting coordinates and numerical data superimposed on map p0224 N72 22633

Post stall aerodynamic characteristics of Harrier GR 1 aircraft and development of lift augmenting devices p0043 N73 15014

Design concept operational performance and military employment of AV 8A Harrier aircraft p0054 N73 27005

**HAWKER SIDDELEY AIRCRAFT**

Operational performance of Hawker Siddeley aircraft automatic flight approach and landing control system p0028 N71 23414

**HEAD (ANATOMY)**

Lethal head injuries to man swimming underwater caused by detonation of firecracker p0100 N72 19135

Protective helmets designed to lessen effects of head injury due to impact in aircraft accidents p0104 N72 19160

Models for head injury prediction and helmets and prediction of optimum helmet performance p0104 N72 19161

Factors standards and techniques involved in testing protective headgear p0104 N72 19162

**HEAD UP DISPLAYS**

Development of heads up flight data display for aircraft approach and landing during all conditions of visibility p0233 N73 23702

**HEALTH PHYSICS**

Health hazards and effects of reflections of personnel exposed to simulated nuclear shock waves in protective shelters p0106 N72 19136

Effects of chemical and radiating agents containing bromine on the rate of cardiovascular and nervous systems of laboratory rats and baboons [AGARD 1499] p0071 N71 17106

**HEARING**

Noise effects on hearing conservation in aircrew and ground support personnel of aerospace operations p0077 N73 17101

**HEART**

Physiological factors possibly contributing to mortality risk among British Air Force pilots p0097 N72 14104

## HELICOPTER PERFORMANCE

## A-35

Influence of turbulence on helicopter design and operation  
analysis of structural loads, pilot workload, and passenger  
comfort affected by atmospheric turbulence  
p0059 N74 17736

# HELICOPTER WAKES

Analytical and experimental techniques to define geom-  
etry of vortex field of hovering rotary wing and effect on  
rotor performance  
p0049 N73 21032

Development of actuator disk theory for predicting  
time averaged downwash distribution and response  
characteristics of rotorcraft rotors in forward flight  
p0049 N73 21033

Development of procedure for determining geometry and  
strength distribution of vortex wake generated by single  
bladed hovering helicopter rotor  
p0049 N73 21035

Analysis of unsteady aerodynamic loading on reference  
section of helicopter rotor blade in axial or hovering flight  
under compressible flow conditions  
p0050 N73 21044

Development of technique for rotor blade design and  
measurement of pressure distributions along the blade chord  
and across blade wake near rotor tip in flight  
p0051 N73 21047

Analysis of aerodynamic noise produced by rotary wings  
and methods for noise reduction based on shed vortex wakes  
and blade tip modification  
p0052 N73 21053

Proceedings of conference on rotary wings to investigate  
rotor wakes, aerodynamic characteristics at hover and high  
advance ratio, and aerodynamic noise properties  
[AGARD AR 61]  
p0052 N73 21051

# HELICOPTERS

Vibration effects on performance of helicopter flight  
cruises  
p0068 N71 20355

Post crash fire safety of helicopter turbine engine fuels  
p0075 N72 11608

Breakdown of automatic pilots or auxiliary stabilization  
systems on helicopters  
p0031 N72 11918

Possibilities and limitations of rotary and fixed wing  
compatible Doppler sensor designs  
p0031 N72 11923

System for increasing helicopter stability  
p0033 N72 11932

Advanced Doppler inertial navigation system for transport  
helicopters  
p0033 N72 11935

Army helicopter accident analysis for reducing impact  
injury problems and helicopter crashworthiness  
p0099 N72 19129

Central digital computers for helicopter guidance and  
control systems  
p0156 N72 21223

Application of model helicopter rotor experiments to  
determining dynamic stall of rotary wings and predicting  
aerodynamic loads developed  
p0017 N73 14002

Numerical analysis of unsteady aerodynamic forces on  
helicopter rotor blades to determine lift distribution as  
function of velocity component normal to blades  
p0017 N73 14003

Helicopter flying in poor light and near-cessless terrain and  
color vision abnormality  
p0078 N73 19075

Application of night vision technology, helicopter night  
sights  
p0033 N73 19970

Analysis of procedures and problems involved in operating  
helicopters from decks of ships  
p0046 N73 21010

Reliability and operational safety of mechanical helicopter  
transmission boxes  
p0047 N73 21012

Aerodynamic dynamic and aerodynamic problems, military  
wing design for helicopters and V-STOL aircraft with  
application to helicopter rotor systems  
p0051 N73 21051

Analysis of helicopter internal and external noise levels  
for various flight conditions and tuning of acoustic  
spectra  
p0052 N73 21055

Fundamentals of helicopter noise generation and propaga-  
tion to include noise control procedures and cost effective  
reduction of noise reduction  
p0017 N73 22953

Analysis of operational problems associated with wind  
tunnel testing of V-STOL aircraft and helicopters  
p0173 N73 26140

Scaling laws, constructional problems, and optimum  
model size associated with wind tunnel tests of helicopters  
and rotary wing aircraft  
p0173 N73 26246

Application of glass, reinforced and carbon reinforced  
composite materials for helicopter structures and rotary  
wings  
p0211 N73 27483

Proceedings of symposium to determine requirements  
and configurations of emergency ejection systems for  
helicopter crews  
[AGARD AR 62]  
p0055 N73 31954

Technical evaluation report on Fluid Dynamics Panel  
Specialists Meeting on Aerodynamic Drag  
[AGARD AR 58]  
p0018 N74 0905

Problems of estimating the drag of a helicopter  
correlation of flight test data and scale model test data  
p0019 N74 14715

# HELIOS PROJECT

Design, development, and characteristics of intercon-  
nected communications HELIOS space probe as example  
p0194 N72 19509

# HELIUM

Turbulent mixing layers between two helium gas streams,  
such as hydrogen and helium  
p0178 N72 20295

# HELMETS

Protective helmets designed to reduce effects of head  
injury due to impact in aircraft accidents  
p0104 N72 19160

Models for head injury prediction and helmets and  
prediction of optimum helmet performance  
p0104 N72 19161

Design, development and testing of helmets for flight  
cruises  
p0104 N72 19162

Biomedical problems with helmet mounted sight and  
visual target acquisition system  
p0303 N73 19969

# HIGH ALTITUDE

Polarization coupling losses on sky wave paths at high  
altitude  
p0129 N72 21145

Conferences on biophysical approaches to solving  
problems of ionizing and nonionizing radiation effects during  
high altitude flight, manned space flight, and ground based  
equipment  
[AGARD CP 95 PT 3]  
p0075 N72 26045

Integrated SAVAN VOR and OME system for locating  
and controlling high altitude aircraft  
p0232 N73 23695

# HIGH ALTITUDE ENVIRONMENTS

Environmental effects on parachute impact injuries at  
6,000 to 10,000 feet using parabolic apex vented static  
line deployed parachute  
p0101 N72 19137

# HIGH ENERGY PROPELLANTS

Possible high energy fuels for supersonic aircraft  
p0251 N72 11670

# HIGH FREQUENCIES

Side scatter propagation at higher frequencies for  
monitoring air pollution using remote optical radar and  
laser techniques  
p0122 N72 16097

Propagation loss, spectral spreading, and temporal  
spreading of high altitude HF signal transmission  
p0129 N72 21144

HF measurements of ocean wave directional spectra  
using Bragg backscatter angle  
p0148 N74 13867

# HIGH PRESSURE

Scorification in rich aerosol flames at high pressure  
p0219 N74 14289

# HIGH SPEED

Flight test evaluation of military aircraft low altitude high  
speed performance  
p0029 N71 23421

Discussion of speed record establishment by SA 341  
helicopter to include aircraft preparation procedures and  
requirements for successful completion  
p0047 N73 21018

# HIGH SPEED CAMERAS

Applications of lasers as indirect light source for high  
speed photography  
p0200 N72 25504

# HIGH STRENGTH ALLOYS

Standardization of test procedures for determining stress  
corrosion cracking in high strength alloys and steels under  
various environments - conference  
[AGARD CP 98]  
p0285 N72 21900

Stress corrosion tests of 2XXX series high strength  
aluminum alloys in laboratory environment  
p0285 N72 21903

Can even bending tests for determining susceptibility of  
high strength alloys to stress corrosion cracking  
p0281 N72 21911

Analysis of crack initiation and crack propagation in high  
strength Al alloys in different environments  
p0288 N72 21918

# HIGH STRENGTH STEELS

Properties and selective applications of high strength  
steels  
p0205 N71 27049

Standardization of test procedures for determining stress  
corrosion cracking in high strength alloys and steels under  
various environments - conference  
[AGARD CP 98]  
p0285 N72 21900

Determination of stress corrosion cracking parameters  
for 300M steel  
p0286 N72 21906

Threshold stress intensity values and crack propagation  
rates for stress corrosion of high strength steels in aqueous  
environment  
p0287 N72 21913

Analysis of stress corrosion for determining crack growth  
rate in high strength centerline steel type specimens  
p0281 N72 21917

Some recent developments in fatigue and fracture  
mechanisms, self-healing of high strength  
steels  
p0204 N74 23110

# HIGH TEMPERATURE

Thermodynamic stability diagrams of high temperature  
O<sub>2</sub> corrosion reactions  
p0070 N71 20362

# HIGH TEMPERATURE ENVIRONMENTS

Human factors requirements when working in extreme  
climate environments  
p0070 N71 20362

Conference on high temperature corrosion of alloys for  
aerospace applications  
[AGARD CP 125]  
p0201 N73 23592

Design and manufacturing of composite materials with  
highly anisotropic properties for use in aerospace vehicle struc-  
tures at high temperatures  
p0212 N73 27489

# HIGH TEMPERATURE GASES

Advanced cooling systems and heat resistant materials  
for high speed flow of high temperature and high speed  
turbine gases  
[AGARD CP 73 PT 1]  
p0251 N73 17312

High advance temperatures for improved performance  
of turboengines and gas turbine engines  
p0252 N73 17313

Heat transfer and radiation measurements on high  
temperature states in high temperature combustion chamber  
p0251 N73 17318

Efficiency of heat exchanger systems for high temperature  
engines  
[NASA TM X 66702]  
p0258 N73 17385

Design of gas turbine engines for high temperature opera-  
tion  
p0248 N73 17386

Design and performance of thermosiphon fluid cooled  
high speed temperature axial flow turbine  
p0260 N71 17399

Computerized optimization of thermal resistant gas  
turbine blades  
p0260 N71 17400

# HIGH TEMPERATURE LUBRICANTS

Assessment of high temperature stability of synthetic  
lubricants for aircraft gas turbines  
p0254 N72 11635

Analysis of lubricant system used in civil supersonic gas  
turbine engine  
p0254 N72 11697

Synthetic high temperature lubricants thickened by  
complex esters for supersonic aircraft  
p0255 N72 11701

# HIGH TEMPERATURE RESEARCH

Conference on high temperature turbines detailing effect  
of film cooling on blade profile loss  
[NASA TM X 67123]  
p0261 N71 22699

Research organizations, investigators, and programs in  
high temperature research from eleven NATO countries and  
Spain  
[AGARD R 585 PT 1]  
p0302 N71 36382

Low cycle fatigue testing at high temperatures  
[AGARD R 604]  
p0292 N73 18916

High temperature corrosion scale for heat resistant  
alloys  
p0201 N73 23598

# HIGH TEMPERATURE TESTS

High temperature environmental testing of gas metal  
interactions to simulate severe operating conditions  
p0202 N73 23606

Analysis of heat transfer properties and thermophysical  
properties of materials used for aircraft and spacecraft  
construction  
[AGARD R 606]  
p0300 N73 25968

# HIGHWAYS

Pattern recognition technique for automatic detection of  
vehicles in aerial photographs of highways  
p0152 N72 11183

# HISTOGRAMS

A distribution for the electroslag remelting method  
concerning the interpretation of histogram characteristics  
vectorial tests to assess motion sickness and disorien-  
tation susceptibility  
p0168 N74 20739

# HISTOLOGY

Personal observations of 340 fatal aircraft accidents for  
confirmation of laterations to victims  
p0099 N72 19124

# HOLOGRAPHY

Holographic pattern recognition using matched filter  
correlation  
p0153 N72 11194

Principles of holography and various methods for produc-  
tion of holograms  
p0199 N72 25495

Mathematical models and numerical analysis of coherent  
optical systems used as holographic reference system  
p0199 N72 25496

Application of aerodynamic holography for optical  
recording and flow visualization in wind tunnels and research  
facilities  
p0199 N72 25498

Principles for producing holograms and methods of  
recording interference pattern between reference beam and  
reflected light waves  
p0199 N72 25499

Calculation of diffraction efficiency and signal to noise  
ratio for two dimensional and volume diffraction gratings  
p0199 N72 25500

Development and characteristics of holographic wave-  
fronts for use with Q-switched ruby lasers  
p0199 N72 25501

[NASA CR 126767]  
Characteristics of solid state ruby laser as application  
for holographic recording  
p0200 N72 25502

# HONEYCOMB STRUCTURES

Controlling free stream turbulence of passive devices  
[AGARD R 598]  
p0182 N72 33267

# HOOKS

Development and characteristics of load carrying hook  
system for use on military transport tank options  
p0048 N73 11022

# HORIZONTAL TAIL SURFACES

Wind tunnel tests with simulation of tailplane interfe-  
rence on European Airbus models  
p0064 N71 19374

Computer programs for calculating aerodynamic charac-  
teristics of wing horizontal tail and fin configurations in  
subsonic flow  
p0064 N71 19342

# HORMONE METABOLISMS

Human pituitary and adrenal hormone reserves and rela-  
tion stress tolerance  
p0105 N73 19150

# HOT PRESSING

Manufacturing of atomic bomb by hot pressing of fuel  
p0258 N72 12593

# HOT WIRE ANEMOMETERS

Flow visualization techniques and hot wire anemometer  
data for shear flow turbulence  
p0178 N72 20290

Hot wire anemometer measurements of turbulent flow in  
subsonic jets  
p0178 N72 20294

# HOVERING

Analysis of operational requirements and feasibility of  
system for precise CH helicopter hovering  
p0023 N72 11934

Evaluation of hovering and flight display for hovering phase  
of R9, as long as 1500 ft altitude  
p0274 N72 26631

Analytical and experimental techniques for determining  
vortex field of hovering rotary wing in relation to  
rotor performance  
p0049 N73 21032

Development of procedure for determining optimum  
vortex field distribution of vortex wake generated by a  
rotor in hovering flight  
p0049 N73 21033

# HOVERING STABILITY

Parameters for stability performance of helicopter  
rotors in hovering state  
p0249 N73 27615





## HYDRAULIC EQUIPMENT

## HYDRAULIC EQUIPMENT

Hydraulic equipment for high Reynolds number testing in transonic wind tunnel  
[NASA TM X 67418] p0015 N72 11880

Characteristics of power generating systems and application to missiles for production of hydraulic and electric energy p0065 N73 19044

Influence of adiabatic oil compression on power of hydraulic motors and pumps p0066 N73 19055  
Hydraulic compressor wind tunnel p0174 N74 16992

## HYDRAULIC FLUIDS

Influence of adiabatic oil compression on power of hydraulic motors and pumps p0066 N73 19055

## HYDROCARBON FUELS

Possible high energy fuels for supersonic aircraft p0251 N72 11670  
Cooling advanced engines by endothermic reactions of hydrocarbon fuels by absorbing sensible and latent heat p0251 N72 11672

Analytical techniques applied to additive and contaminant analysis in advanced hydrocarbon fuels with polar compound and fluoride impurities p0251 N72 11673

Adiabatic compression method for determining self-ignition delay in hydrocarbon air fuel mixtures p0252 N72 11682

## HYDRODYNAMIC CALCULATIONS

Hydrodynamic calculation and experimental observations of ionospheric shock front propagation following nuclear explosion p0137 N73 14150

## HYDRODYNAMICS

Numerical approximation of non-Zachary-Kowalewski systems in hydrodynamics p0181 N72 27295

## HYDROGEN

Ultrahigh vacuum for determining effects of hydrogen on fatigue and fracture properties of Ti 200 p0287 N72 21916

## HYPERBOLIC NAVIGATION

Optimization of integrated navigation systems combining several independent navigation sensors to provide self-contained aircraft navigation capability p0229 N73 20694

Aircraft inertial system testing and evaluation in the United Kingdom p0237 N74 14352

## HYPERCAPNIA

Physiological responses to interacting stresses of exercise and hypercapnia under acute and chronic exposure to ambient P<sub>50</sub> CO<sub>2</sub> of 21 mm Hg p0070 N71 20370

## HYPERSONIC AIRCRAFT

Kerosene type fuel for supersonic and hypersonic aircraft p0251 N72 11670

## HYPERSONIC FLOW

Acoustic wave drag p0018 N74 14709  
Drag in hypersonic flow: effects of cold pressure drag and friction drag p0221 N74 14730

The influence of wave drag on hypersonic airfoil wake observations: flow regimes in wake of blunt body viscous flow p0222 N74 14733

Review of drag measurements from flight tests of manned aircraft with comparison to wind tunnel predictions p0222 N74 14735

## HYPERSONIC NOZZLES

Starting conditions of mixed compression axisymmetric hypersonic nozzles p0267 N72 16715

## HYPERSONIC SPEED

Heat transfer and pressure distribution rates and profile pressure profiles for turbulent boundary layers in subsonic and hypersonic speeds p0179 N72 20301

## HYPERSONIC WIND TUNNELS

Facilities for aerodynamic testing at hypersonic speeds p0174 N74 16993

## HYPERTENSION

Elevated blood pressure in a crew p0085 N74 13187

## HYPERVELOCITY PROJECTILES

Sequential spark electron beam fluorescence probe and electrostatic probe array methods for measuring turbulent wake properties of hypersonic spheres p0178 N72 20296

## HYPOXIA

Partial cerebral hypoxic attacks in pilots as cause of hypoxic incidents p0088 N74 18786

## HYSTERESIS

Analysis of effect of damping on response of structure to acoustic excitation and experimental method for determining damping coefficient p0293 N73 29917

## ICE FORMATION

Acoustic wave radar sensor for depth sounding in Antarctic ice p0123 N72 16099

## ICE MAPPING

Analysis of ice map data p0016 N73 16088  
Design and performance of microwave radiometer for accurate sensing of sea ice thickness p0121 N72 16089

## IGNITION

Adiabatic compression method for determining self-ignition delay in hydrocarbon air fuel mixtures p0252 N72 11682

Theoretical analysis of fuel ignition by surface film and ignition delay time as function of temperature and Lewis of fuel mixture p0252 N72 11683

Crash safe turbine fuel programs using gelled fuels p0253 N72 11687

## ILLUMINATION

Applications of lasers as indirect light source for high speed photography p0200 N72 21504

Application of incoherent and coherent light sources for underwater illumination and comparison of efficiency for various conditions p0242 N73 33633

## IMAGE CORRELATORS

Holographic pattern recognition using multichannel correlator p0153 N72 11184

Techniques for predicting effects of thermal and saline inhomogeneities on optical imaging systems with application to optical properties of sea water p0241 N73 33625

Effects of resolution, signal to noise ratio, and contrast on underwater imaging systems performance p0242 N73 33631

## IMAGE ENHANCEMENT

Application of spatial filtering and image restoration to underwater photographs of foodlit images p0242 N73 33637

## IMAGES

Radar pattern recognition for image data processing with meteorological radar systems p0151 N72 11183

## IMAGING TECHNIQUES

Algorithm for reducing redundancy during image transmission p0131 N73 10189

Techniques for predicting effects of thermal and saline inhomogeneities on optical imaging systems with application to optical properties of sea water p0241 N73 33625

Effects of resolution, signal to noise ratio, and contrast on underwater imaging systems performance p0242 N73 33631

Application of spatial filtering and image restoration to underwater photography of foodlit images p0242 N73 33637

## IMPACT

Catapult system for launching automobiles and impact studies p0103 N72 19153

## IMPACT DAMAGE

Lethal heat fluxes to man swimming underwater caused by detonation of live rocket p0100 N72 19135

Neurophysiological observation of spinal fracture and a facial facial deformation patterns in ches monkeys [AMR 73 117] p0101 N72 19139

## IMPACT TESTS

Crash safe turbine fuel programs using gelled fuels p0253 N72 11687

Crash injury research including pathology and protection p0098 N72 19120

Theoretical mechanics for expressing kinematics of human impact and acceleration using two coordinate systems p0100 N72 19132

Equipment design for accurately measuring mechanical response of man during impact p0102 N72 19145

Indoor testing of vehicle impact p0103 N72 19154

Acceleration protection system design impact testing of restraint harnesses and ejection seat cushions and implications p0104 N72 19157

Anthropometry for protective equipment evaluation and human impact acceleration experiments p0084 N73 23066

## IMPULSES

Relationship of interaction of impulsive and steady to peripheral motor performance in human beings p0069 N71 20361

## IN FLIGHT MONITORING

Anticollision equipment for approach path control in reduced noise trajectories of Boeing transport aircraft p0029 N71 23425

In-flight data acquisition and processing systems p0195 N73 10452

On-board computer systems for flight information and space shuttle support of flight crew p0289 N73 33933

## INCOMPRESSIBLE FLOW

Unsteady pressure measurements on harmonically oscillating swept wing with two control surfaces in incompressible flow p0013 N71 25350

Equations for time mean values of incompressible turbulent flow and eddy viscosity dependence on second invariant of deformation tensor p0176 N72 20289

Partial differential equations for calculating three dimensional incompressible turbulent boundary layers p0177 N72 20285

Analysis of velocity profiles in boundary layer produced by incompressible flow through rough p0047 N71 15201

Longitudinal momentum balance in incompressible flow through cavities with rough walls p0269 N73 19862

## INCOMPRESSIBLE FLUIDS

Navier-Stokes equation solutions incompressible fluid in bounded domain p0181 N72 27298

## INDEXES (DOCUMENTATION)

Subject and author indexes and abstracts of documents [AGARD R 578 71] p0031 N73 17432

A computer program to keyword code a system for retrieval of reports in the Library of the Aeronautical Research Association [AGARD R 578 71] p0158 N74 16926

Time line of research in aerodynamics and aerodynamics [AGARD R 578 71] p0104 N74 17664

## INDUSTRIES

Heat exchanger process alternatives in steel p0299 N72 18449

Design of large area and small area systems for commercial application p0158 N72 27173

## SUBJECT INDEX

Design and operational services of small data centers to technical users [AGARD CP 117] p0158 N73 24201

Functions of small industrial information center p0158 N73 24203

Information dissemination services to industry p0159 N73 24210

## INITIAL GUIDANCE

Inertial guidance systems components and technology applied to control and guidance of tactical missiles p0227 N72 27690

Inertial guidance techniques for midcourse guidance and terminal guidance systems with application to control and guidance of tactical standoff missiles p0227 N72 27691

Development and evaluation of failure detection and isolation technique for use with four gimbaled inertial measuring units p0228 N73 20687

Development of low cost inertial measurement unit with navigational accuracy performance based on optimum size design of inertial instruments and platform p0228 N73 20690

Design optimization of SRAM inertial navigation and guidance p0230 N73 20705

Laboratory tests of accelerometer arrays used in inertial guidance systems in French military programs p0231 N73 20714

Introductory remarks: Test technology trends applied to performance tests of inertial guidance systems p0236 N74 14346

PIGA: Acceleration tests on vertical 10G 3 Hz table centrifuge and vibration tests of inertial guidance systems p0236 N74 14347

Inertial guidance system centrifuge testing development and characteristics of test equipment p0236 N74 14348

Laboratory evaluation of electro-optically aided space navigation systems: demonstration of design concept and hardware performance p0236 N74 14350

Aircraft Navigation systems testing with a high precision reference development of Completely Integrated Reference Instrumentation System (CIRIS) p0237 N74 14353

Inertial guidance system sled testing p0237 N74 14354

## INERTIAL NAVIGATION

Gyroscopic theory and applications to inertial guidance and navigation: vehicle fabrication and related bibliography [AGARD R 582 71] p0189 N71 21422

Advanced Doppler inertial navigation system for transport vehicles p0033 N72 15355

Navigation guidance computer requirements for integrated navigation system using combination of outputs of inertial, Doppler and total equipment p0158 N72 27694

Proceedings of conference on inertial navigation: components and systems with emphasis on concepts and techniques involving cost and performance tradeoffs [AGARD CP 116] p0227 N73 20684

Numerical analysis of effects of various parameters affecting accuracy and stability of strapdown inertial navigation systems p0227 N73 20685

Research activities of electronics laboratory in development of inertial navigation systems for wide applications for space missions and commercial aircraft p0227 N73 20686

Development of rapid installation of inertial navigation system using aircraft wide area navigation p0228 N73 20693

Optimization of integrated navigation systems combining several independent navigation sensors to provide self-contained aircraft navigation capability p0229 N73 20694

Contributions of inertial navigation systems to the flight control p0229 N73 20695

Application of computer-aided programming of navigation platforms in strike aircraft p0230 N73 20704

Design and evaluation of SRAM inertial navigation and guidance p0230 N73 20705

Parameters of single axis floated gyroscopes when used in inertial systems requiring rapid gyrocompassing to significant p0231 N73 20709

A 7-axis attitude control and shipboard inertial navigation system methodology p0231 N73 20710

Design of Pengo in situ inertial navigation system for midcourse guidance p0231 N73 20713

Fast rotation and magnetoelastic concepts of a low cost inertial navigation system p0231 N73 20713

Methods employed to reduce data errors and redundancy information for evaluation of inertial navigation systems and identification of error sources p0232 N73 20716

Life cycle cost analysis of inertial navigation systems for aircraft and space vehicles p0232 N73 20717

Characteristics of three gyroscopes used in inertial and applications to inertial navigation systems p0232 N73 20718

Analysis of North Atlantic area system for determining impact of inertial navigation on satellite navigation separation facilities p0233 N73 20699

Testing of photonic inertial navigation system and inertial systems and their use in application to navigation systems for aircraft and space vehicles p0236 N74 14345

Life cycle cost analysis of inertial navigation systems for aircraft and space vehicles p0232 N73 20717

Characteristics of three gyroscopes used in inertial and applications to inertial navigation systems p0232 N73 20718



- Jet blowing for intake boundary layer control in V-STOL aircraft p0264 N72 18697
- Performance criteria including engine air flow matching requirements of asymmetric mixed compression intake for supersonic transport p0265 N72 18703
- Free jet tests of full scale supersonic intake engine combination of Concord power plant p0265 N72 18704
- Design problems of inlets and nozzles used in supersonic and V-STOL precursor systems [NASA TM X 67741] p0267 N72 21819
- INTEGRATED CIRCUITS**
- Development and characteristics of microelectronic equipment for improved reliability and reduced weight and size of electronic components p0191 N72 19484
- Computer aided design for electronic circuits conference [AGARD CP 130] p0165 N74 13906
- Unit transistor. Model of bipolar transistor having continuous parameters as the geometric dimensions p0166 N74 13917
- Structure and application of computer program ICAN. Integrated circuit AC analysis p0167 N74 13926
- Computer aided design analysis of modern large scale circuits and subsystems p0167 N74 13928
- SIGMA. An integrated system of computer aided complex circuit designs p0168 N74 13932
- Computer aided placement and routing of high density chip interconnection systems p0168 N74 13937
- INTELLIGENCE**
- Research and development program for military geophysical information system using airborne radar and multispectral photographic data p0171 N72 16086
- INTERFERENCE**
- Program design for study of engine aircraft interference problems p0263 N72 16686
- INTERFERENCE DRAG**
- Aerodynamic interference characteristics of airframe propulsion systems of transport and military aircraft [AGARD CP 71 71] p0001 N71 19353
- Wind tunnel vortex flow study on body of revolution with or without wings p0001 N71 19355
- Optimization of interference between aircraft components in supersonic flow p0001 N71 19356
- Finite element computer program for estimating airplane aerodynamic interference [NASA TM X 66884] p0001 N71 19357
- Lift and drag interference characteristics of delta winged half cones with leading edges p0002 N71 19359
- Numerical analysis of downwash interference on wings of missile tails p0002 N71 19360
- Calculation methods for wing body interference drag on supersonic aircraft in stationary or unstationary flow p0002 N71 19362
- Interference flow field of thin flat plate configuration in supersonic turbulent boundary layer channel p0003 N71 19365
- Flight and wind tunnel evaluation of flow field effects on performance of supersonic underwing exhaust nozzle at transonic speeds [NASA TM X 66887] p0003 N71 19366
- Aircraft afterbody and engine nozzle interferences at subsonic, transonic, and supersonic speeds [NASA TM X 66888] p0003 N71 19368
- Interference effect between oscillating and distorted inlet flow on compressor stall p0003 N71 19370
- Wind tunnel surveys of flow fields about wing fuselage store configuration inlets of transonic and supersonic aircrafts [NASA TM X 66885] p0004 N71 19371
- Aerodynamic flow field interference effects on supersonic inlets p0004 N71 19372
- Wind tunnel tests with jetson glider of airplane interference on European aircraft models p0004 N71 19374
- Aerodynamic interference effects on BAC aircraft p0004 N71 19375
- Wind tunnel evaluation of interference drag in turbulent engine wing configuration of subsonic aircraft p0004 N71 19376
- Computer program for determining forward interference effects of flow fields about arbitrary bodies by superposition p0005 N71 19377
- Photographic recording of aerodynamic interference in wind tunnel simulation of jetson glider p0005 N71 19378
- Flow field interference beneath swept wing fuselage store installation on aircraft p0005 N71 19380
- Computerized prediction of interference flow field for wing fuselage store for all omni bomber aircraft p0005 N71 19381
- Wind tunnel studies of external store and jet flow field instability effects on longitudinal stability of arrow wing aircraft p0005 N71 19382
- Flight test measurements of interference and steady aerodynamic drag effects caused by positioning of external stores from F-2 aircraft p0006 N71 19384
- Computerized prediction of flow field interference in inlets and exhausts on aircraft stores at subsonic speeds p0006 N71 19385
- Qualitative and quantitative data on aerodynamic wind tunnel tests of interaction between engine flow and wing components in transonic wind tunnels p0006 N71 19387
- Computation of interference in supersonic flow on engine airframe interference in transonic flow p0006 N71 19389
- Wind tunnel tests for airplanes with interference with transonic wind tunnel tests p0006 N71 19390

- Interference problems of airframe engine integration in aircraft design optimization [AGARD LS 53] p0037 N72 27016
- Engine airframe interference corrections in calculating model aircraft performance from wind tunnel test data p0037 N72 27017
- Integration of forebody and forebody wing flow fields into airplane design criteria p0037 N72 27018
- Wind tunnel models for determining inlet interference and performance of inlet airframe combination in supersonic aircraft design p0037 N72 27019
- Wind tunnel test results of exhaust nozzle airframe interference drag for optimization of subsonic aircraft design p0037 N72 27020
- Wind tunnel test requirements for simulating nozzle parameters and nozzle airframe interference characteristics p0037 N72 27021
- Determination of thrust and drag characteristics for integrated aircraft engine design optimization p0038 N72 27023
- The drag of externally carried stores. Its prediction and alleviation. Drag reduction by redesign or development of new aircraft installations p0021 N74 14729
- Strong interference effects on afterbodies at transonic speeds p0022 N74 14737
- INTERFERENCE LIFT**
- Aerodynamic interference effects between wing and fuselage junctions p0001 N71 19354
- Lift and drag interference characteristics of delta winged half cones with leading edges p0002 N71 19359
- Computerized prediction of aerodynamic lifting characteristics for wing horizontal tail and canard wing configurations [NASA TM X 66886] p0002 N71 19361
- Numerical analysis of aerodynamic loads on wing and tail surfaces with oscillations in unsteady supersonic and subsonic flow including interference lift [AGARD CP 80 71 PT 1] p0007 N71 29333
- Wing interference lift in the lattice simulation and application to aerodynamic loads on tandem wings in unsteady flow p0008 N71 29336
- Interference lifting surfaces in unsteady subsonic flow. Comparison between theory and experiment [AGARD R 614] p0023 N74 18654
- INTERFEROMETERS**
- Principles for producing holograms and methods of recording interference pattern between reference beam and reflected light waves p0199 N72 25499
- INTERFEROMETRY**
- Application of laser beams for measurement of aerodynamic flow fields at supersonic and hypersonic speeds p0200 N72 25503
- INTERMODULATION**
- Multipath transmission models for predicting signal distortion and intermodulation in tropospheric scatter propagation p0119 N71 23463
- INTERNATIONAL COOPERATION**
- Proposal for international oral pollution information analysis center p0113 N71 19531
- Feasibility of creating international marine pollution information analysis center p0113 N71 19532
- International survey of air pollution by aircraft engines and fuels [AGARD AR 40] p0212 N72 21590
- German cooperation in international atmospheric pollution research p0304 N72 20959
- International pollution seminar and p0306 N74 23495
- INTERVALS**
- Gravity wave effects on ionospheric time changes of daily traveling ionospheric disturbances p0138 N73 14156
- INTOXICATION**
- Physiological and behavioral effects of alcohol and based on preclinical laboratory experiments p0072 N72 25039
- Alcohol induced postural, functional, and behavioral effects of alcohol intoxication in primates p0075 N72 25060
- INVISCID FLOW**
- Development of procedures for determining planar inviscid supersonic flow over airfoils [AGARD AG 156] p0016 N72 22101
- Numerical analysis of supersonic flow due to accelerating cylinder and cone in steady subsonic flow p0181 N72 27362
- Extension of two-dimensional technique for wave field flow flow to three-dimensional flow p0182 N72 27363
- Computation of transonic inviscid flow with embedded shock waves p0182 N72 27366
- Development of algorithm for calculating flow about arbitrary three-dimensional bodies p0182 N72 27367
- Calculation of supersonic flow over airframe interference in transonic flow p0051 N71 25048
- ION ACOUSTIC WAVES**
- Acoustic wave network for statistical and single event structural vibration morphology and wave propagation analysis p0127 N72 21127
- Radar wave propagation at 1295 MHz p0127 N72 21130
- Radar wave propagation at 1295 MHz p0127 N72 21131
- IONIZATION**
- Ionospheric plasma effects on ground and field wave propagation at HF and UHF in Northern Hemisphere p0119 N72 23462

# IONIZING RADIATION

- Natural ionizing radiation effects on multiplication of unicellular organisms and *Drosophila melanogaster* development p0075 N72 26050

## IONOGRAMS

- Iono-grams and morphological statistics of polarized E conditions emphasizing two stream or plasma ion wave instability p0130 N72 21148

## IONOSPHERE

- Characteristics and effects of Arctic ionosphere on radar and radar propagation conference [AGARD CP 97] p0126 N72 21121
- Models of Arctic ionosphere p0126 N72 21127
- Intensity of weak scattering from electron density irregularities in ionosphere p0128 N72 21134
- Development of optical stratigraphy and Doppler spectrum broadening due to barium plasma in ionosphere p0128 N72 21136
- Radio signals from Explorer 22 for ionospheric electron content p0128 N72 21141
- Durnal variations in ionospheric electron magnetic dipole equation due to gravity waves p0138 N73 14160
- Total electron content of ionosphere with emphasis on North Atlantic region [AGARD AG 166] p0187 N73 27350

## IONOSPHERIC DISTURBANCES

- Ionospheric irregularities causing high latitude satellite scintillation p0128 N72 21140
- Sweep frequency backscatter radar as detectors of high latitude ionospheric phenomena p0129 N72 21147
- High frequency backscatter observations of high latitude field aligned irregularities in F region p0130 N72 21149
- Ionospheric reflection effect on quality of field aligned ionization at HF and UHF in Northern Hemisphere p0130 N72 21152
- Nuclear source model for generating ionospheric disturbances through acoustic gravity waves p0135 N73 14141
- Full wave solution for electron density perturbations caused by gravity waves in F2 region p0136 N73 14145
- Ionospheric disturbances caused by infrasonic waves propagating from thunderstorms p0136 N73 14148
- Ionospheric gravity wave electric amplitudes and spectra p0137 N73 14149
- Hydrodynamic calculations and experimental observations of ionospheric shock front propagation following nuclear explosion p0137 N73 14150
- High frequency radar backscatter technique for determining ionospheric structure and gravity wave disturbances p0137 N73 14155
- Continuous wave Doppler radar observations of ionospheric disturbances generated by Saturn Apollo launchings p0138 N73 14157
- Ionospheric disturbance effects on sky wave bearing measurement p0138 N73 14159
- Infra-sound detection of propagating atmospheric shock waves caused by supersonic aircraft p0138 N73 14161
- Theoretical plasma perturbation model for calculating coupling effects between acoustic gravity waves and electromagnetic waves in ionospheric disturbances p0138 N73 14162
- Nonlinear propagation and ionospheric coupling of atmospheric waves following nuclear explosion p0140 N73 14168
- F-layer electron density fluctuations and disturbances following nuclear explosion at ionospheric height p0140 N73 14169

## IONOSPHERIC ELECTRON DENSITY

- Ionospheric gravity wave electron amplitudes and spectra p0137 N73 14149
- F-layer electron density fluctuations and disturbances following nuclear explosion at ionospheric height p0140 N73 14169
- Effects of acoustic gravity waves following nuclear explosion on ionospheric electron density and on the ionospheric ionospheric conditions p0140 N73 14170

## IONOSPHERIC SCATTER PROPAGATION

- Solar radio interference for traveling ionospheric disturbance detection p0138 N73 14158

## IONOSPHERIC PROPAGATION

- Ionospheric propagation model and application to high latitude HF radar propagation p0130 N72 21153
- Observations of wave and ionospheric emission during magnetic storms caused by ionospheric irregularities p0130 N72 21158
- Estimation of ionospheric electron density from frequency propagation techniques for measuring a small gravity wave in ionosphere. Oregon p0137 N73 14153
- Atmospheric gravity wave effects on ionospheric traveling ionospheric wave propagation in the case of traveling ionospheric disturbances p0139 N73 14164

## IONOSPHERIC STORMS

- Relationship between atmospheric gravity waves and spatial ionospheric irregularities p0136 N73 14146

## IONOSPHERICS

- Acoustic gravity waves and ionospheric p0126 N72 21125

## ISOTHERMAL PROCESSES

- Rate of isothermal processes in water during isobaric and isochoric expansion p0202 N73 23625

## ISOTHERMAL TURBULENCE

- Effect of isothermal turbulence on the rate of isothermal expansion p0126 N72 21125

## ITALY

Flight thermal conditions affecting acceleration tolerance and psychomotor performance of flying personnel p0084 N73 23068

## ITERATIVE SOLUTION

The double iteration method in structural optimization p0298 N74 15615

## J

## JAMMING

Kirman filtering algorithm for detecting continuous wave interference signals in digital telecommunications p0133 N73 10210

## JET AIRCRAFT

Wind tunnel tests with jet simulation of airplane interference on European Airbus models p0004 N71 19374

Synthesis and properties of aliphatic ester for turbine lubrication in jet aircraft p0354 N72 11696

Role of jet surgeon and physician in evaluation and treatment of jet fighter pilots p0395 N72 14094

Methods for evaluating and predicting airfield performance of fighter aircraft for aircraft operating in non-convex and short takeoff modes p0053 N73 24044

Development of two methods for optimizing design of subsonic swept wing jet transport aircraft p0054 N73 24054

## JET ENGINE FUELS

Jet fuel specifications for military and civil aircraft p0251 N72 11659

European jet fuel toxicity evaluation p0252 N72 11679

Flammability properties of jet fuels and techniques for fire and explosion suppression under simulated flight operating environment conditions p0252 N72 11681

Properties of chemical portion of jet engine. The impact of its incomplete combustion p0053 N73 24044

Formaldehyde contamination by jet petroleum fuels p0218 N74 14383

## JET ENGINES

Properties and selective applications of high intensity steels, aluminum and titanium alloys, polymers, composites, materials, and composite materials in aircraft engineering p0205 N71 27038

Properties and selective applications of titanium alloys in aircraft and engines p0206 N71 27045

Analysis of the properties and properties required to conduct test of jet aircraft engine models in wind tunnels p0173 N73 26245

Acoustometric measurements of exhaust noise from jet engines p0221 N74 14319

The problem of cooling a jet engine. High bypass engine on a twin jet transport aircraft p0021 N74 14327

## JET FLAPS

M-126 jet flap. A jet flap aircraft development and testing p0027 N73 20666

Development of jet flap aircraft application to heavy helicopter and transport helicopter p0048 N73 21027

Transonic drag during short takeoff jet flap aircraft p0020 N74 14322

## JET FLOW

Properties of jet flow for vertical takeoff aircraft p0265 N72 16769

Turbulent boundary layer jets and wakes in confined spaces p0275 N72 16773

A study of flow separation in the base region of a bluff body in a supersonic flow. External flow over a blunt body in a free stream flow p0020 N74 14324

## JET IMPINGEMENT

Analysis of surface pressure fluctuations from jet impingement on a flat plate with application to jet aircraft with external flow p0292 N73 29939

## JET MIXING FLOW

Rapid mixing of jet flow with a free stream flow p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

Flow characteristics of jet flow in a duct p0020 N74 14324

## JETTISONING

Photographic recording of aerodynamic interference on wind tunnel simulation of jettisoned drop loads from aircraft p0005 N71 19378

Computerized prediction of separated store trajectories dropped from bomber aircraft at high speed p0005 N71 19379

Flight test measurements on interference and aerodynamic drag effects caused by jettisoning of external stores from F-2 aircraft p0006 N71 19384

Wind tunnel evaluation of lifting body store configurations for jettisoned drag and separation characteristics p0006 N71 19386

Statistical prediction of external store separation characteristics from aircraft p0006 N71 19388

Ground-to-air jettisoning by jet jettisoned from aircraft p0218 N74 14383

## JOINTS (ANATOMY)

Necropsy and radiographic observation of spinal fracture and articular facet dislocation patterns in thesis monkeys p0101 N72 19139

## JOINTS (JUNCTIONS)

Amplitude and phase effects in effects between wing and fuselage junction p0001 N71 19354

## K

## KALMAN FILTERS

Kalman filtering algorithm for detecting and tracking wave interference signals in digital telecommunications p0133 N73 10210

Fast detection of target motion in Kalman filtering system employing Kalman filtering p0133 N73 10212

## KALMAN SCHMIDT FILTERING

Recursive filters for adaptive learning Bayesian optimal adaptive pattern recognition with unknown target p0153 N72 11189

Development and application of Kalman filter techniques for target detection and tracking p0226 N72 27685

Application of Kalman filter to target tracking and Kalman filter algorithm for target tracking p0229 N73 20700

## KERNEL FUNCTIONS

Method for calculating kernel functions for interference analysis p0079 N73 29345

Kernel functions for pressure distribution over wings with laminar flow separation p0009 N71 29145

## KEROSENE

Kerosene type fuel for supersonic aircraft engines p0251 N72 11659

## KINEMATICS

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

Kinematic analysis of aircraft motion in a multiple wing aircraft p0079 N73 29345

## LAMINATES

Response of general laminated plates to applied loads with coupling between bending and extensional modes of deformation p0212 N73 21483

Computer aided design of multilayer printed circuit boards p0168 N74 13934

Optimizing automatic stacking of multilayer boards p0168 N74 13935

## LAND USE

Analysis of satellite multispectral imagery data for tropical land use interpretations p0124 N72 16111

## LANDING AIDS

Requirements for using Telenor landing aid as portable ground station in tactical helicopter operations p0032 N72 11925

Development of heads up flight data display for aircraft approach and landing during all conditions of visibility p0233 N73 23702

## LANDING SIMULATION

Accuracy of vertical contact analog display in simulating carrier landings and takeoffs contributed by display resolution temporal loading and control complexity p0225 N72 27642

Simulation of carrier deck landing process in dynamic landing operations on a ship p0280 N73 23899

## LANGUAGE PROGRAMMING

Generation of a system of LEL (Language Expression Language) programs to express semantic content of English like sentences in a special intermediate language p0151 N72 11177

## LARGE SCALE INTEGRATION

Large scale integration of digital logic circuits p0168 N74 13933

## LASER MATERIALS

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

## LASER MODE LOCKING

Properties of laser materials for laser materials research p0199 N72 25494

## LASER MODES

Properties of laser materials for laser materials research p0199 N72 25494

## LASER OUTPUTS

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

Properties of laser materials for laser materials research p0199 N72 25494

## LATTICES (MATHEMATICS)

### LATTICES (MATHEMATICS)

Kinematics of subsonic unsteady airloads on multiple lifting surfaces p0008 N71 29339

### LEADING EDGE SLATS

Design aspects of stall of powered lift aircraft with externally blown flaps and methods for predicting increment in maximum lift coefficient due to power p0042 N73 15011

### LEADING EDGE SWEEP

Flaps and leading edge modifications for improved aerodynamic control stability of military aircraft p0029 N71 23422

### LEADING EDGES

Representations of flow separation bubbles near airfoil leading edge p0027 N71 20764  
Development of method for calculating small separation zones near leading edge of airfoil at incidence p0041 N73 15002

### LEARNING MACHINES

Recursive filters for supervised learning: Bayes optimal adaptive pattern recognition with continuous data p0153 N72 11185

### LENSES

Characteristics of lenses and ports for underwater imaging systems to compare depth of field and relative aperture for several lens port combinations p0242 N73 33635

### LESIONS

Optic field hysteria: Its value in the diagnosis of certain vestibular lesions human abnormal neurophysiological responses in the presence of brain stem lesions p0109 N74 20742

### LIBRARIES

Problems of library and information services to large research center p0158 N73 24704

### LIFE SUPPORT SYSTEMS

Effectiveness of phased diffusion compared to current demand diluter oxygen delivery system p0083 N73 23565

### LIFT AUGMENTATION

Aerodynamics and applications of lift augmentation devices AGARD lecture series [AGARD LS 43 71] p0025 N71 20651

High lift systems design for combat aircraft p0026 N71 20659

Lift augmentation devices effect on STOL engine Part 1: interface problems between engine and airframe p0026 N71 20661

Lift augmentation devices effect on STOL engine Part 2: thermodynamic problems p0026 N71 20662

Optimizing propulsive lift system for turbofan STOL aircraft considering cost effectiveness p0026 N71 20663

High lift wing characteristics wing with plan hinged flaps and boundary layer control and wing with drag and high lift devices extended p0027 N71 20665

Aerodynamics of two dimensional flow on high lift systems p0027 N71 20667

Propulsive lift technology program for development of short takeoff aircraft propulsion systems and lift augmentation devices p0055 N73 27009

Design development and evaluation of Bellair Spay Augmentation Wing research aircraft using internally blown flap for lift augmentation p0055 N73 27010

### LIFT DEVICES

Aerodynamics and applications of lift augmentation devices AGARD lecture series [AGARD LS 43 71] p0025 N71 20651

Aerodynamic effects of mechanical high lift devices on conventional aircraft p0025 N71 20652

Aerodynamics of pneumatic high lift devices p0025 N71 20653

Flow separation concepts for high lift devices p0025 N71 20655

Two dimensional wind tunnel tests on airfoils with high lift devices p0025 N71 20656

Three dimensional testing of high lift device models p0026 N71 20657

High lift applications to transport aircraft design p0026 N71 20658

High lift systems design for combat aircraft p0026 N71 20659

Lift augmentation devices effect on STOL engine Part 1: interface problems between engine and airframe p0026 N71 20661

Lift augmentation devices effect on STOL engine Part 2: thermodynamic problems p0026 N71 20662

High lift wing characteristics wing with plan hinged flaps and boundary layer control and wing with drag and high lift devices extended p0027 N71 20665

Aerodynamics of two dimensional flow on high lift systems p0027 N71 20667

Kinematics of subsonic unsteady airloads on multiple lifting surfaces p0008 N71 29339

Application of lifting surface theory to wing with control surfaces: constant velocity flow p0029 N71 29337

Transonic wind tunnel tests of effects of sweep on high lift devices on swept airfoil airfoils controlling flow separation p0042 N73 15011

Development of high experimental apparatus for a swept two dimensional flow on high lift devices p0042 N73 15011

Characteristics of lifting surfaces: constant velocity flow: Comparison between theory and experiment [AGARD P 674] p0029 N74 19544

### LIFT DRAG RATIO

Transonic wind tunnel determination of blunt trailing edge effects on drag and lift characteristics of wing profile p0012 N72 11862

### LIFT FANS

Thrust measurement interpretation for V-STOL models and transition performance of lift fan configurations p0264 N72 16693

### LIFTING BODIES

Techniques and procedures for conducting flight tests of lifting body type aircraft during transonic and supersonic flight conditions [NASA TM X 68306] p0035 N72 20986

Drag of lifting bodies for pilots at high altitude p0021 N74 14731

### LIGHT (VISIBLE RADIATION)

Characteristics of imaging radiometers installed in meteorological satellites for observing infrared and visible regions p0192 N72 19497

### LIGHT ALLOYS

Development of experimental program for determining response and sonic fatigue resistance of lightweight aircraft structures p0294 N73 29923

### LIGHT SCATTERING

Effect of ocean depth on light scattering and attenuation parameters to include optical properties influenced by concentration size and shape of particulate matter p0241 N73 33626

Mathematical theories for determining light propagation by sea water p0241 N73 33627

Light scattering by particles in sea water based on volume scattering function and point spread function p0242 N73 33628

Measurement of light scattering at various angles using point spread function and modular transformation on function techniques p0242 N73 33629

Effect of various parameters on long range underwater vision for narrow and broad beam illumination p0242 N73 33630

Application of Fourier techniques to calculate spread of scattered light for circular spot Gaussian profile and near shore cases p0242 N73 33632

### LIGHT TRANSMISSION

Proceedings of underwater computer simulation and optical properties of sea water for application to surveillance mapping communications and visibility [AGARD LS 61] p0241 N73 33619

Radiance distribution as function of depth in upper layers of ocean and numerical analysis of coherent and apparent optical properties p0241 N73 33621

Optical properties of pure and turbid sea water p0241 N73 33624

Effect of ocean depth on light scattering and attenuation parameters to include optical properties influenced by concentration size and shape of particulate matter p0241 N73 33626

Light scattering by particles in sea water based on volume scattering function and point spread function p0242 N73 33628

Effect of various parameters on long range underwater vision for narrow and broad beam illumination p0242 N73 33630

Application of Fourier techniques to calculate spread of scattered light for circular spot Gaussian profile and near shore cases p0242 N73 33632

Apparatus for coherent and coherent light sources for underwater communication and comparison of efficiency for various conditions p0242 N73 33633

Lincoln experimental satellites integrated preprocessing system for line extraction in binary pictures p0153 N72 11192

Linear programming Reduction of nonlinear programming problems to sequence of linear programming problems p0283 N71 20133

Recent developments in the Case-optimal path program using mathematical programming approach p0296 N74 15600

Integer programming algorithms for optimum aircraft design p0296 N74 15604

Stochastic programming algorithm for aircraft design and scheduling problems p0297 N74 15605

### LINEAR SYSTEMS

General analysis of ad hoc operations with a given set of linear systems coupled together a general method of linear systems p0226 N72 27684

Linear transformations Multiple coding method for analog signal processing p0125 N72 16314

Scanned field generation by transducer flow rate generated signals in wind tunnels p0014 N72 11876

### LIPID METABOLISM

Thyroid induced hyperlipidemia: Type and distribution of changes in the HDL:AEM can increase disease susceptibility p0087 N74 13897

### LIQUID BEARINGS

Development of optical film thickness measuring technique for liquid bearings p0229 N73 29995

### LIQUID BREATHING

Effects of positive G<sub>y</sub> acceleration on blood oxygen saturation and pleural pressure relations in dogs breathing an anesthetic liquid fluorocarbons in whole body water immersion respiration [NASA CR 117199] p0088 N71 20358

### LIQUID COOLING

Design and performance of thermophon fluid cooled high entry temperature axial flow turbine p0260 N71 17399

### LIQUID METALS

Heat transfer in liquid metal cooled gas turbine blades p0260 N71 17398

Development of superconducting homopolar machines with multiple disks and superconducting field winding using liquid metals for armature winding controls p0064 N73 19037

### LIQUID PROPELLANT ROCKET ENGINES

Heat transfer processes in liquid propellant rocket engines [AGARD AG 148 71] p0299 N72 12950

### LIVER

Management of asymptomatic carriers of hepatitis associated antigen in Hellenic Air Force personnel p0083 N73 23060

### LOADS (FORCES)

Response of general laminated plates to applied loads with coupling between bending and extensional modes of deformation p0212 N73 27488

Summaries of papers presented to AGARD conference on random load fatigue [AGARD AR 54] p0292 N73 28884

### LOGIC CIRCUITS

Using cellular logic for pattern recognition p0154 N72 11108

Specification and design languages for logic systems p0168 N74 13930

### LOGIC DESIGN

Computer aided placement and routing of high density chip interconnection systems p0168 N74 13937

### LOGISTICS

Development and characteristics of dual cargo hook system for use on military transport helicopters p0048 N72 21022

### LONG TERM EFFECTS

Residual effects of hypoxic drugs on human nervous function and performance p0080 N73 21106

Pilot performance and sleep patterns in long duration flights and control of hypoxic drug and alcohol use p0080 N73 21107

Physiological aspects of sleep induction in aircrews after prolonged flight times p0080 N73 21108

Effects of isomand treatment on pilot performance p0080 N73 21111

### LONG WAVE RADIATION

Statistical evaluation of fading caused by intermodulation in combined long wave broadband propagation [CNFT NT 65T APH 1] p0117 N71 21453

### LONGITUDINAL CONTROL

Influence of load and wing load distribution on lateral and longitudinal maneuverability of aircraft p0044 N73 16998

### LONGITUDINAL STABILITY

Effects of thrust characteristics on longitudinal stability superior flight p0044 N73 16997

Influence of pilot and aircraft characteristics on structural loads in operational flight: requirements for improved means of flight instruments to reduce control problems [AGARD P 698] p0058 N74 17128

### LORAN

Navigation and time computer requirements for integrated navigation systems using combination of outputs of Loran C Doppler and other equipment p0014 N72 21424

Application of long range navigation system and Kalman filter algorithm to fixed feedback gain p0229 N73 29701

Characteristics of a time area navigation computer and application to air traffic control function p0234 N73 23698

HF measurements of ocean wave low frequency spectra using B and C tracks after range p0148 N74 13867

### LORAN C

Application of airborne digital computers to Loran C D and Omega navigation and guidance systems p0157 N72 21225

### LORAN D

Application of airborne digital computers to Loran C D and Omega navigation and guidance systems p0157 N72 21225

### LOW ALTITUDE

Flight test evaluation of constant altitude low altitude flight performance p0029 N71 27423

High speed low altitude flight control systems for military helicopters p0037 N72 11924

Terrain avoidance radar for US Army rotary wing aircraft p0132 N72 11927

### LOW SPEED STABILITY

Analysis of propeller effects on low speed stability and stall characteristics of high speed aircraft p0045 N73 14999

### LOW SPEED WIND TUNNELS

Low speed wind tunnel tests of the effects of air wake with various duct configurations on the flow over a high angle of attack p0267 N72 17618

## SUBJECT INDEX

- Low speed wind tunnel investigation of rotor flow boundary layer flow along streamwise direction  
[AGARD R 602] p0183 N73 26279
- Objectives of dynamic tests in low speed wind tunnel and techniques for measuring oscillatory derivatives and transient motion effects  
[AGARD R 602] p0183 N73 26244
- Fluid motion problems in design and operation of low speed and transonic wind tunnels  
[AGARD R 602] p0183 N73 26279
- Probabilities of wind tunnel design and testing  
[AGARD R 602] p0173 N74 16997
- Some conclusions of future low speed tunnel for Europe  
[AGARD R 602] p0173 N74 16988
- LOW TEMPERATURE ENVIRONMENTS**  
Human factors requirements when working in extreme climatic environments  
p0070 N71 20167
- LOW VISIBILITY**  
Method for calculating weather minima for single sites to determine whether to attempt approach, performance requirements for military helicopters  
p0031 N72 11919
- LUBRICANT TESTS**  
Properties evaluation of lubricant and fuel by use of a new gas chromatograph  
[NASA CR 122842] p0254 N71 11634
- LUBRICANTS**  
Aircraft fuels, lubricants and fuel safety considerations  
[AGARD CP 84 21] p0251 N72 11688
- European jet fuel safety evaluation  
p0252 N72 11679
- Development of aircraft fuels and lubricants to meet the performance requirements of the future  
[AGARD AR 44] p0255 N72 27871
- LUBRICATING OILS**  
Aircraft methods for early stage detection of oil degradation and leakage  
p0254 N72 11698
- The availability of lubricating oil for aircraft engines  
p0254 N72 11699
- LUBRICATION**  
Synthetic oil properties of aircraft engine lubricants  
p0254 N72 11698
- LUMINANCE**  
Relationship between luminance and color in aircraft engine oil displays  
p0223 N72 22943
- LUNAR MODULE**  
Design of lunar module for lunar surface operations  
p0098 N71 13749

## M

- MACH NUMBER**  
Measurement of drag coefficient  
p0023 N74 14739
- MACHINE ORIENTED LANGUAGES**  
The use of machine oriented languages for the design of control systems  
p0013 N72 11729
- Development of machine oriented languages for the design of control systems  
p0013 N72 11730
- Extension of machine oriented languages for the design of control systems  
p0013 N72 11731
- MAGNETIC EQUATOR**  
The magnetic equator in the Earth's magnetic field  
p0013 N72 11732
- MAGNETIC FIELDS**  
The magnetic field in the Earth's magnetic field  
p0013 N72 11733
- MAGNETIC LENSES**  
The magnetic field in the Earth's magnetic field  
p0013 N72 11734
- MAGNETIC PROPERTIES**  
The magnetic field in the Earth's magnetic field  
p0013 N72 11735
- MAGNETIC STORMS**  
The magnetic field in the Earth's magnetic field  
p0013 N72 11736
- MAGNETOHYDRODYNAMIC GENERATORS**  
The magnetic field in the Earth's magnetic field  
p0013 N72 11737
- MAGNETOMETERS**  
The magnetic field in the Earth's magnetic field  
p0013 N72 11738

- MAGNUS EFFECT**  
Magnus effect in a fluid flow  
p0013 N72 11739
- MAINTENANCE**  
Maintenance of aircraft systems  
p0013 N72 11740
- MAP MACHINE SYSTEMS**  
Human factors in aircraft navigation  
p0013 N72 11741
- MAP MATCHING GUIDANCE**  
Application of map matching guidance to aircraft navigation  
p0013 N72 11742
- MAPS**  
Map matching guidance  
p0013 N72 11743
- MARKING**  
Marking of aircraft systems  
p0013 N72 11744
- MARTENSITIC STAINLESS STEELS**  
Martensitic stainless steels  
p0013 N72 11745
- MASS FLOW**  
Mass flow measurement  
p0013 N72 11746
- MASS RATIOS**  
Mass ratios in aircraft systems  
p0013 N72 11747
- MASS SPECTROMETERS**  
Mass spectrometers  
p0013 N72 11748
- MASS TRANSFER**  
Mass transfer in aircraft systems  
p0013 N72 11749
- MATERIALS**  
Materials in aircraft systems  
p0013 N72 11750
- MATERIALS HANDLING**  
Materials handling in aircraft systems  
p0013 N72 11751
- MATERIALS SCIENCE**  
Materials science in aircraft systems  
p0013 N72 11752
- MATERIALS TESTS**  
Materials tests in aircraft systems  
p0013 N72 11753
- MANAGEMENT**  
Management in aircraft systems  
p0013 N72 11754
- MANAGEMENT METHODS**  
Management methods in aircraft systems  
p0013 N72 11755
- MANEUVERABILITY**  
Maneuverability in aircraft systems  
p0013 N72 11756
- MANNED SPACE FLIGHT**  
Manned space flight  
p0013 N72 11757
- MANUAL CONTROL**  
Manual control in aircraft systems  
p0013 N72 11758
- MANUFACTURING**  
Manufacturing in aircraft systems  
p0013 N72 11759

- MAP MATCHING GUIDANCE**  
Application of map matching guidance to aircraft navigation  
p0013 N72 11742
- MAPS**  
Map matching guidance  
p0013 N72 11743
- MARKING**  
Marking of aircraft systems  
p0013 N72 11744
- MARTENSITIC STAINLESS STEELS**  
Martensitic stainless steels  
p0013 N72 11745
- MASS FLOW**  
Mass flow measurement  
p0013 N72 11746
- MASS RATIOS**  
Mass ratios in aircraft systems  
p0013 N72 11747
- MASS SPECTROMETERS**  
Mass spectrometers  
p0013 N72 11748
- MASS TRANSFER**  
Mass transfer in aircraft systems  
p0013 N72 11749
- MATERIALS**  
Materials in aircraft systems  
p0013 N72 11750
- MATERIALS HANDLING**  
Materials handling in aircraft systems  
p0013 N72 11751
- MATERIALS SCIENCE**  
Materials science in aircraft systems  
p0013 N72 11752
- MATERIALS TESTS**  
Materials tests in aircraft systems  
p0013 N72 11753
- MANAGEMENT**  
Management in aircraft systems  
p0013 N72 11754
- MANAGEMENT METHODS**  
Management methods in aircraft systems  
p0013 N72 11755
- MANEUVERABILITY**  
Maneuverability in aircraft systems  
p0013 N72 11756
- MANNED SPACE FLIGHT**  
Manned space flight  
p0013 N72 11757
- MANUAL CONTROL**  
Manual control in aircraft systems  
p0013 N72 11758
- MANUFACTURING**  
Manufacturing in aircraft systems  
p0013 N72 11759

- Mathematical models for calculating turbulent boundary layer injected with gas p0180 N72 2303
- Mathematical models for determining flight performance of Concord aircraft p0734 N72 20978
- Kirk model for determining susceptibility of Zn-Mg-Cu aluminum alloys to stress corrosion crack growth p0287 N72 21915
- MATHEMATICAL MODEL FOR FLUID MECHANICS**  
p0182 N72 27308
- Electron flow model for predicting performance characteristics of supersonic electron systems p0183 N72 17251
- One- and two-D core theories for analyzing ducted mixing and burning of coaxial streams p0183 N72 17253
- Finite difference procedure for computing behavior of two-dimensional boundary layers and turbulence model to predict location and extent of transition region p0268 N73 19796
- Analytical approach for loss and deflection behavior of cascades in transonic flow including axial mass flow variation p0268 N73 19800
- Calculation method for external heat transfer to turbine blades p0269 N73 19807
- Method for prediction of turbulent boundary layer flow in vanes radial diffuser and experimental validation p0270 N73 19809
- Mathematical model for prediction of axial compressor performance including effect of annulus wall boundary layers p0270 N73 19812
- Model for inherent contrast conditions in full form objects p0303 N73 19966
- Mathematical models for measuring inertial qualities of spherical gyroscopes with electric suspension p0228 N73 20691
- Mathematical model for measuring operating functions and performance of gyroscopes with two degrees of freedom p0229 N73 20696
- Estimation procedures for in-flight vertical misalignment of platforms p0230 N73 20707
- Modeling error sensitivity of digital filters for alignment of inertial platforms p0230 N73 20708
- Differential method for evaluating performance of nonlinear accelerometers p0231 N73 20715
- Mathematical models of aircraft launch performance p0553 N73 24047
- Mathematical theories for determining light propagation by sea water p0241 N73 23627
- Computational and analytical determination of HCS p0244 N74 11956
- Use of radio modeling data for radio target assessment p0245 N74 11965
- Shallow water Model of bipolar transistor having continuous parameters as the geometric dimensions p0166 N74 13917
- Theoretical study of the radial evolution of rotating products in turbine exhausts p0220 N74 14794
- Development and validation of an analytical model for predicting emissions from gas turbine engine combustors during low power operation p0220 N74 14795
- Modeling of turbomachine nonburners for pollutant studies p0220 N74 14798
- Necessary and sufficient conditions for global stability of optically p0295 N74 15697
- Shape optimization in mathematical categorization and modeling techniques p0297 N74 15695
- Numerical treatment of fluid dynamical stability problems p0185 N74 22921
- MATRICES (MATHEMATICS)**  
Wing interference with line fatigue simulation and application to aerodynamic loads on tail fin wings in steady flow p0008 N71 27336
- Applying thinning process to matrix of black and white dots for numeral recognition p0153 N72 11191
- MATRIX METHODS**  
Matrix method for calculating adaptive prewhitening filter for radar echo signal processing p0131 N73 10197
- MAXWELL EQUATION**  
Maxwell field theory for solving wave paths in inhomogeneity in tropospheric water propagation p0119 N71 23467
- MEASURING INSTRUMENTS**  
Equipment design for accurately measuring mechanical response of man during impact p0102 N72 19145
- Procedure for determining noise levels in flight test engine systems p0195 N73 19456
- MECHANICAL DEVICES**  
Aerodynamic effects of mechanical high lift devices on conventional airfoils p0025 N71 20952
- MECHANICAL DRIVES**  
Reliability and operational safety of mechanical drive power transmission boxes p0047 N71 21017
- MECHANICAL PROPERTIES**  
Growth and crack associated with fatigue in high temperature gas turbine materials p0253 N71 17189
- Structural data on the thermoplastic materials for use in designing flexible vehicles p0255 N73 20927
- Properties and service applications of composite strength steels, glass fiber and carbon fiber, polymeric matrix, carbon fiber materials, and composite materials in aerospace or marine p0255 N71 27038
- Properties and selective applications of high strength steels p0255 N71 27049
- Properties and selective applications of engineering materials p0255 N71 27041
- MECHANICAL PROPERTIES OF FIBER REINFORCED MATERIALS**  
p0206 N71 27043
- Properties and selective applications of aluminum alloys in airframe construction p0206 N71 27044
- Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials conference [AGARD CP 63 71] p0206 N72 12492
- Mechanical properties of silica fiber reinforced epoxy composite materials p0207 N72 12493
- Temperature and fiber orientation effects on mechanical behavior of silicon dioxide epoxy composite materials p0207 N72 12499
- Techniques, applications and scope of fractography [AGARD AG 155 71] p0285 N72 13887
- Structural and mechanical characteristics of human connective tissue p0101 N72 19140
- Mechanical properties and stress corrosion of hot rolled alloy plates p0289 N72 21931
- Relationship between effective properties of fiber composite materials and mechanical and geometric properties of their constituents p0209 N72 29590
- Techniques for measuring elastic, viscoelastic, ultimate strength, thermal and electrical properties of fiber reinforced composites p0209 N72 29593
- Comparing characteristics of advanced composites with those of conventional airframe materials p0210 N72 29595
- Chemical and mechanical properties of aircraft gas turbine engine components p0201 N73 23600
- Metallurgical aspects of fatigue and fracture toughness conference on effects of microstructure on mechanical properties of airframe materials [AGARD R 610] p0204 N74 23108
- MEDICAL ELECTRONICS**  
Processing and display of time varying electrical formation with application to human voice and biomedical signals p0154 N72 11209
- MEDICAL EQUIPMENT**  
Equipment and facilities for body area research in U.S. and Canada p0095 N71 23342
- Equipment and facilities for body area research in NATO Europe countries p0095 N71 23343
- Practical problems in clinical magnetography in Guidelines for selection of equipment for body area research p0108 N74 20734
- MEDICAL SCIENCE**  
A clinical model of diagnosis using nonparametric sequential pattern classification properties p0152 N72 11184
- MEDICAL SERVICES**  
Role of flight surgeon and physician pilot in evaluation and treatment of fighter pilots p0095 N72 14094
- MEDICINE**  
Sports medicine parameters necessary for maximizing competitive form p0081 N73 21114
- MEDITERRANEAN SEA**  
Numerical models of total electron content over Europe and the Mediterranean and multi station ionospheric comparisons [AGARD AG 156A] p0107 N74 14084
- A numerical model of the sea level Mediterranean area p0187 N74 14086
- MENTAL HEALTH**  
Handbook of aviation medicine for safe mental and physical health of aircrew during flight [AGARD AG 154] p0071 N72 24058
- MENTAL PERFORMANCE**  
Organic and chemical effects of physiological stress on mental and physical performance p0092 N71 23312
- Mental and physiological environmental performance in unaided flight p0088 N74 14787
- METABOLISM**  
Metabolic indicators and body hypophysics during food deprivation for 10 days p0070 N71 20368
- Influence of long duration flight on various metabolic and endocrine functions of pilots and navigators p0106 N73 19152
- METAL FATIGUE**  
Ultimate values for determining effects of frequency on fatigue and fracture properties of Ti-200 p0281 N72 21916
- METAL MATRIX COMPOSITES**  
Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials conference [AGARD CP 63 71] p0206 N72 12492
- Stress of an fatigue in the work of fiber reinforced aluminum composites having high glass fiber matrix p0208 N72 12504
- Analysis of structural diffusion in basis between regularities of anisotropic materials p0278 N72 12517
- Analysis of properties of fiber reinforced materials with plastic matrix for the prediction and application to gas turbine engine p0210 N73 27476
- Production of fiber reinforced composites by rolling of powder with strong anisotropy with application to composite vehicle structure p0210 N73 27478
- Application of fiber reinforced materials to composite weight structures for low cost in production of aircraft structural parts p0211 N73 27485
- Development of fiber reinforced composite materials for application to aircraft engine components p0212 N73 27497
- METAL OXIDE SEMICONDUCTORS**  
Application of complementary metal oxide semiconductor to design of integrated circuits used with spacecraft electronic equipment and commercial equipment p0181 N72 19486
- Application of complementary MOS circuits in pulse code modulation systems for photogrammetry of X-ray region of solar corona and in operation of quartz clock with PCM output p0192 N72 19501
- METAL PLATES**  
Analysis of response and fatigue characteristics of light alloy integrally machined plates with emphasis on acoustic fatigue properties p0293 N73 29912
- Improvement of the properties of high strength Al-Zn-Mg-Cu alloys by thermomechanical procedures ductility, toughness and stress corrosion properties of steel plates and forgings p0204 N74 23111
- METAL SURFACES**  
Intermodulation interference effects of metal surface transmitters and receivers in near field of atomic transition system p0134 N73 10212
- Influence of surface preparation, surface texture, and initial oxidation on metal surface crystallization p0201 N73 23603
- METAL WORKING**  
Improvement of the properties of high strength Al-Zn-Mg-Cu alloys by thermomechanical procedures ductility, toughness and stress corrosion properties of steel plates and forgings p0204 N74 23111
- METALS**  
Dilatometric thermal expansion measurements on high temperature structural materials p0213 N71 23358
- Materials and designs of protective armor p0102 N72 19143
- Standardization of test methods for stress corrosion in metals p0285 N72 21907
- METEOR TRAILS**  
Radar observation of meteor trails for detecting high altitude gravity waves p0173 N73 14154
- METEOROLOGICAL PARAMETERS**  
ATS 5 inch wide 15 GHz Doppler propagation parameter based radar and meteorological data p0115 N71 21418
- Topographic scatter propagation and radar meteorological transition zone characteristics p0117 N73 23451
- Radio attenuation prediction method using statistical atmospheric level indices p0129 N72 23468
- Meteorological effects on tropospheric propagation of radio waves for telecommunication p0129 N71 23476
- Statistical forecast of signal attenuation with topographic scatter using meteorological parameters p0120 N71 23475
- Tropospheric propagation in an equivalent medium p0148 N74 13865
- Influence of medium and high frequency ionospheric layer formation on frequency for near and far distance p0057 N74 17721
- Influence of medium and high frequency ionospheric layer formation on frequency for near and far distance p0057 N74 17723
- A technique expressed in formulae for evaluation of atmospheric visibility through an traffic control meteorological data reports and pilot experience p0058 N74 17727
- METEOROLOGICAL RADAR**  
Real time weather radar data in tropospheric microwave attenuation by rain p0114 N71 23416
- Radar pattern recognition for image data processing with meteorological parameters p0114 N72 14087
- Ultra high frequency precipitation attenuation measurement by ATS 5 inch wide radar at 140 MHz p0113 N73 26147
- METEOROLOGICAL SATELLITES**  
Characteristics of imaging radiometers installed in meteorological satellites for observing infrared and visible regions p0192 N72 19497
- METHANE**  
Effects of chemical reactions, strong agents, containing hydrogen sulfide methane and carbon dioxide and nitrogen systems of dogs in monkeys and baboons [AGARD R 599] p0077 N73 17196
- MICROELECTRONICS**  
Development and characteristics of microelectronic equipment for improved reliability and reduced weight and size of electronic components p0191 N72 19484
- High frequency of microelectronic equipment for improved reliability and reduced weight p0191 N72 19487
- MICROFILMS**  
Microfilm test procedures system which is a function of a reference scale and film properties for microfilm display technology well defined trace and reference p0157 N72 22169
- Development of a microfilm test system for the evaluation of computer display technology for application to electronic data processing p0158 N72 22171
- Integrated microfilm and microfilm processing system for data processing in a computer p0159 N71 24276
- Microfilm test procedures system for a state of the art system p0160 N74 14912
- Microfilm test procedures system for a state of the art system p0160 N74 14912

**MICROPHOTOGRAPHS**

- New developments in storage, retrieval, dissemination of aerial and information p0159 N74 16925
- [AGARD CP 1361] p0159 N74 16925
- Retrieval of microfiche Random access p0160 N74 16934
- A microfiche system for small use p0160 N74 16935
- A computer controllable microfiche terminal p0160 N74 16936
- Abstracts on microfiche for on-line retrieval p0161 N74 16937

**MICROSTRUCTURE**

- Properties and selective applications of high strength steels p0205 N72 27040
- Microstructure and stress corrosion behavior of welded steel joints p0286 N72 21910
- Microscopic characteristics of stress corrosion cracking in steel with high yield strength p0289 N72 21925
- Analysis of microplasticity of materials used in inertial navigation systems to show the origin of stress and rate of strain hardening in microstructure p0278 N73 20693
- Metallographic analysis of fatigue and fracture toughness: correlation of effects of the microstructure on the mechanical properties of aerospace materials p0204 N74 23108
- Summary of developments in fatigue and fracture mechanics relating to the design of stress and fatigue resistant steels p0204 N74 23110

**MICROWAVE ATTENUATION**

- Real-time weather radar data on topographic microwave attenuation p0174 N72 24456
- Measurement of microwave attenuation by precipitation by ATIS Satellite beam p0175 N72 24459
- Water vapor attenuation of microwave propagation over sea surface p0140 N73 26125
- Attenuation and phase dispersion of a microwave in atmosphere due to oxygen in microwave spectrum p0141 N73 26126
- High depolarization of energy in a microwave spectrum p0141 N73 26127
- Use of differential phase shift for rain rate estimation and of a rain rate estimator for rain rate estimation p0141 N73 26132
- Rain attenuation and its impact on the design of microwave radio relay systems p0142 N73 26134
- Measurement of rain rate by using the differential phase shift of a microwave signal p0142 N73 26135

**MICROWAVE CIRCUITS**

- State of the art in the design of complete design of microwave integrated circuits p0166 N74 13918
- Complete design of microwave integrated circuits p0166 N74 13919
- DAR Development of a Microwave Processor A program for the design of a microwave processor p0166 N74 13921
- Microwave circuit analysis by digital computer p0166 N74 13922

**MICROWAVE EQUIPMENT**

- Feasibility evaluation of microwave ground-to-airborne equipment for helicopter approach and landing guidance system p0134 N72 17935
- Application of microwave portable equipment for tracking of airborne systems using radio wave data links in the terminal region p0227 N72 27693
- Microwave radar detection and processing of space and ground targets p0137 N73 24452
- Development of a microwave radar system for tracking system with emphasis on the small target detection for a future equipment p0234 N73 27779
- Development of a microwave radar system and techniques for estimating effects of multiple targets p0234 N73 27780

**MICROWAVE FREQUENCIES**

- ATIS System for the future signal propagation compared to ground level radio communication data p0135 N73 21478

**MICROWAVE IMAGERY**

- Current and prospective applications of microwave radar and photogrammetric systems for ground-to-airborne data link and satellite high resolution imagery [AGARD CP 90-14] p0121 N72 16988
- Ground-to-airborne imagery for microwave radar and photogrammetric systems p0121 N72 16989
- Development of a microwave radar system for ground-to-airborne data link and satellite high resolution imagery p0121 N72 16990

**MICROWAVE RADIOMETERS**

- Design and development of microwave radiometer for a future spaceborne system p0121 N72 16989

**MICROWAVE SCATTERING**

- Scattering of microwave radiation by the ground surface p0141 N73 26133
- Estimation of the surface roughness and scattering of a microwave signal by the ground surface p0141 N73 26134
- Scattering of microwave radiation by the ground surface p0141 N73 26135

**MICROWAVE SENSORS**

- Status of microwave sensors for ground-to-airborne data link and satellite high resolution imagery p0121 N72 16989

**MICROWAVE TRANSMISSION**

- Design of a microwave propagation model for ground-to-airborne data link and satellite high resolution imagery p0121 N72 16989

- Troposphere effects on microwave propagation over the ground p0121 N73 20711
- The radar cross section of a target using a microwave radar system p0121 N73 20712
- Parabolic and non-parabolic radar systems p0121 N73 20713

**MIDAIR COLLISIONS**

- Performance tests of an air traffic control system to determine effectiveness in prevention of mid-air collisions p0215 N73 23713

**MIDCOURSE GUIDANCE**

- Design of a midcourse guidance navigation system for a missile p0211 N73 20711

**MILITARY AIR FACILITIES**

- Airfield construction developed by U.S. military forces and developments in improved airfield control systems p0232 N73 23699

**MILITARY AIRCRAFT**

- Physical vulnerability of aircraft volume 1 [AGARD AR 47 VOL 1] p0061 N74 13501
- Physical vulnerability of aircraft volume 2 [AGARD AR 47 VOL 2] p0061 N74 13502
- Military applications of a STOL aircraft p0061 N74 13503
- High lift system design for military aircraft p0061 N74 13504
- Flight testing of military aircraft for high lift and performance in STOL operations p0061 N74 13505
- Flight test evaluation of military aircraft low altitude performance p0061 N74 13506
- Role of high lift and high speed in military aircraft p0061 N74 13507
- Flight test evaluation of military aircraft low altitude performance p0061 N74 13508
- Flight test procedures for determining the capability of military aircraft p0061 N74 13509
- Electronic identification systems for military aircraft p0061 N74 13510
- A review of military aircraft design and development p0061 N74 13511
- Design of a military aircraft p0061 N74 13512
- Design of a military aircraft p0061 N74 13513
- Design of a military aircraft p0061 N74 13514
- Design of a military aircraft p0061 N74 13515
- Design of a military aircraft p0061 N74 13516
- Design of a military aircraft p0061 N74 13517
- Design of a military aircraft p0061 N74 13518
- Design of a military aircraft p0061 N74 13519
- Design of a military aircraft p0061 N74 13520
- Design of a military aircraft p0061 N74 13521
- Design of a military aircraft p0061 N74 13522
- Design of a military aircraft p0061 N74 13523
- Design of a military aircraft p0061 N74 13524
- Design of a military aircraft p0061 N74 13525
- Design of a military aircraft p0061 N74 13526
- Design of a military aircraft p0061 N74 13527
- Design of a military aircraft p0061 N74 13528
- Design of a military aircraft p0061 N74 13529
- Design of a military aircraft p0061 N74 13530
- Design of a military aircraft p0061 N74 13531
- Design of a military aircraft p0061 N74 13532
- Design of a military aircraft p0061 N74 13533
- Design of a military aircraft p0061 N74 13534
- Design of a military aircraft p0061 N74 13535
- Design of a military aircraft p0061 N74 13536
- Design of a military aircraft p0061 N74 13537
- Design of a military aircraft p0061 N74 13538
- Design of a military aircraft p0061 N74 13539
- Design of a military aircraft p0061 N74 13540
- Design of a military aircraft p0061 N74 13541
- Design of a military aircraft p0061 N74 13542
- Design of a military aircraft p0061 N74 13543
- Design of a military aircraft p0061 N74 13544
- Design of a military aircraft p0061 N74 13545
- Design of a military aircraft p0061 N74 13546
- Design of a military aircraft p0061 N74 13547
- Design of a military aircraft p0061 N74 13548
- Design of a military aircraft p0061 N74 13549
- Design of a military aircraft p0061 N74 13550
- Design of a military aircraft p0061 N74 13551
- Design of a military aircraft p0061 N74 13552
- Design of a military aircraft p0061 N74 13553
- Design of a military aircraft p0061 N74 13554
- Design of a military aircraft p0061 N74 13555
- Design of a military aircraft p0061 N74 13556
- Design of a military aircraft p0061 N74 13557
- Design of a military aircraft p0061 N74 13558
- Design of a military aircraft p0061 N74 13559
- Design of a military aircraft p0061 N74 13560
- Design of a military aircraft p0061 N74 13561
- Design of a military aircraft p0061 N74 13562
- Design of a military aircraft p0061 N74 13563
- Design of a military aircraft p0061 N74 13564
- Design of a military aircraft p0061 N74 13565
- Design of a military aircraft p0061 N74 13566
- Design of a military aircraft p0061 N74 13567
- Design of a military aircraft p0061 N74 13568
- Design of a military aircraft p0061 N74 13569
- Design of a military aircraft p0061 N74 13570
- Design of a military aircraft p0061 N74 13571
- Design of a military aircraft p0061 N74 13572
- Design of a military aircraft p0061 N74 13573
- Design of a military aircraft p0061 N74 13574
- Design of a military aircraft p0061 N74 13575
- Design of a military aircraft p0061 N74 13576
- Design of a military aircraft p0061 N74 13577
- Design of a military aircraft p0061 N74 13578
- Design of a military aircraft p0061 N74 13579
- Design of a military aircraft p0061 N74 13580
- Design of a military aircraft p0061 N74 13581
- Design of a military aircraft p0061 N74 13582
- Design of a military aircraft p0061 N74 13583
- Design of a military aircraft p0061 N74 13584
- Design of a military aircraft p0061 N74 13585
- Design of a military aircraft p0061 N74 13586
- Design of a military aircraft p0061 N74 13587
- Design of a military aircraft p0061 N74 13588
- Design of a military aircraft p0061 N74 13589
- Design of a military aircraft p0061 N74 13590
- Design of a military aircraft p0061 N74 13591
- Design of a military aircraft p0061 N74 13592
- Design of a military aircraft p0061 N74 13593
- Design of a military aircraft p0061 N74 13594
- Design of a military aircraft p0061 N74 13595
- Design of a military aircraft p0061 N74 13596
- Design of a military aircraft p0061 N74 13597
- Design of a military aircraft p0061 N74 13598
- Design of a military aircraft p0061 N74 13599
- Design of a military aircraft p0061 N74 13600
- Design of a military aircraft p0061 N74 13601
- Design of a military aircraft p0061 N74 13602
- Design of a military aircraft p0061 N74 13603
- Design of a military aircraft p0061 N74 13604
- Design of a military aircraft p0061 N74 13605
- Design of a military aircraft p0061 N74 13606
- Design of a military aircraft p0061 N74 13607
- Design of a military aircraft p0061 N74 13608
- Design of a military aircraft p0061 N74 13609
- Design of a military aircraft p0061 N74 13610
- Design of a military aircraft p0061 N74 13611
- Design of a military aircraft p0061 N74 13612
- Design of a military aircraft p0061 N74 13613
- Design of a military aircraft p0061 N74 13614
- Design of a military aircraft p0061 N74 13615
- Design of a military aircraft p0061 N74 13616
- Design of a military aircraft p0061 N74 13617
- Design of a military aircraft p0061 N74 13618
- Design of a military aircraft p0061 N74 13619
- Design of a military aircraft p0061 N74 13620
- Design of a military aircraft p0061 N74 13621
- Design of a military aircraft p0061 N74 13622
- Design of a military aircraft p0061 N74 13623
- Design of a military aircraft p0061 N74 13624
- Design of a military aircraft p0061 N74 13625
- Design of a military aircraft p0061 N74 13626
- Design of a military aircraft p0061 N74 13627
- Design of a military aircraft p0061 N74 13628
- Design of a military aircraft p0061 N74 13629
- Design of a military aircraft p0061 N74 13630
- Design of a military aircraft p0061 N74 13631
- Design of a military aircraft p0061 N74 13632
- Design of a military aircraft p0061 N74 13633
- Design of a military aircraft p0061 N74 13634
- Design of a military aircraft p0061 N74 13635
- Design of a military aircraft p0061 N74 13636
- Design of a military aircraft p0061 N74 13637
- Design of a military aircraft p0061 N74 13638
- Design of a military aircraft p0061 N74 13639
- Design of a military aircraft p0061 N74 13640
- Design of a military aircraft p0061 N74 13641
- Design of a military aircraft p0061 N74 13642
- Design of a military aircraft p0061 N74 13643
- Design of a military aircraft p0061 N74 13644
- Design of a military aircraft p0061 N74 13645
- Design of a military aircraft p0061 N74 13646
- Design of a military aircraft p0061 N74 13647
- Design of a military aircraft p0061 N74 13648
- Design of a military aircraft p0061 N74 13649
- Design of a military aircraft p0061 N74 13650
- Design of a military aircraft p0061 N74 13651
- Design of a military aircraft p0061 N74 13652
- Design of a military aircraft p0061 N74 13653
- Design of a military aircraft p0061 N74 13654
- Design of a military aircraft p0061 N74 13655
- Design of a military aircraft p0061 N74 13656
- Design of a military aircraft p0061 N74 13657
- Design of a military aircraft p0061 N74 13658
- Design of a military aircraft p0061 N74 13659
- Design of a military aircraft p0061 N74 13660
- Design of a military aircraft p0061 N74 13661
- Design of a military aircraft p0061 N74 13662
- Design of a military aircraft p0061 N74 13663
- Design of a military aircraft p0061 N74 13664
- Design of a military aircraft p0061 N74 13665
- Design of a military aircraft p0061 N74 13666
- Design of a military aircraft p0061 N74 13667
- Design of a military aircraft p0061 N74 13668
- Design of a military aircraft p0061 N74 13669
- Design of a military aircraft p0061 N74 13670
- Design of a military aircraft p0061 N74 13671
- Design of a military aircraft p0061 N74 13672
- Design of a military aircraft p0061 N74 13673
- Design of a military aircraft p0061 N74 13674
- Design of a military aircraft p0061 N74 13675
- Design of a military aircraft p0061 N74 13676
- Design of a military aircraft p0061 N74 13677
- Design of a military aircraft p0061 N74 13678
- Design of a military aircraft p0061 N74 13679
- Design of a military aircraft p0061 N74 13680
- Design of a military aircraft p0061 N74 13681
- Design of a military aircraft p0061 N74 13682
- Design of a military aircraft p0061 N74 13683
- Design of a military aircraft p0061 N74 13684
- Design of a military aircraft p0061 N74 13685
- Design of a military aircraft p0061 N74 13686
- Design of a military aircraft p0061 N74 13687
- Design of a military aircraft p0061 N74 13688
- Design of a military aircraft p0061 N74 13689
- Design of a military aircraft p0061 N74 13690
- Design of a military aircraft p0061 N74 13691
- Design of a military aircraft p0061 N74 13692
- Design of a military aircraft p0061 N74 13693
- Design of a military aircraft p0061 N74 13694
- Design of a military aircraft p0061 N74 13695
- Design of a military aircraft p0061 N74 13696
- Design of a military aircraft p0061 N74 13697
- Design of a military aircraft p0061 N74 13698
- Design of a military aircraft p0061 N74 13699
- Design of a military aircraft p0061 N74 13700
- Design of a military aircraft p0061 N74 13701
- Design of a military aircraft p0061 N74 13702
- Design of a military aircraft p0061 N74 13703
- Design of a military aircraft p0061 N74 13704
- Design of a military aircraft p0061 N74 13705
- Design of a military aircraft p0061 N74 13706
- Design of a military aircraft p0061 N74 13707
- Design of a military aircraft p0061 N74 13708
- Design of a military aircraft p0061 N74 13709
- Design of a military aircraft p0061 N74 13710
- Design of a military aircraft p0061 N74 13711
- Design of a military aircraft p0061 N74 13712
- Design of a military aircraft p0061 N74 13713
- Design of a military aircraft p0061 N74 13714
- Design of a military aircraft p0061 N74 13715
- Design of a military aircraft p0061 N74 13716
- Design of a military aircraft p0061 N74 13717
- Design of a military aircraft p0061 N74 13718
- Design of a military aircraft p0061 N74 13719
- Design of a military aircraft p0061 N74 13720
- Design of a military aircraft p0061 N74 13721
- Design of a military aircraft p0061 N74 13722
- Design of a military aircraft p0061 N74 13723
- Design of a military aircraft p0061 N74 13724
- Design of a military aircraft p0061 N74 13725
- Design of a military aircraft p0061 N74 13726
- Design of a military aircraft p0061 N74 13727
- Design of a military aircraft p0061 N74 13728
- Design of a military aircraft p0061 N74 13729
- Design of a military aircraft p0061 N74 13730
- Design of a military aircraft p0061 N74 13731
- Design of a military aircraft p0061 N74 13732
- Design of a military aircraft p0061 N74 13733
- Design of a military aircraft p0061 N74 13734
- Design of a military aircraft p0061 N74 13735
- Design of a military aircraft p0061 N74 13736
- Design of a military aircraft p0061 N74 13737
- Design of a military aircraft p0061 N74 13738
- Design of a military aircraft p0061 N74 13739
- Design of a military aircraft p0061 N74 13740
- Design of a military aircraft p0061 N74 13741
- Design of a military aircraft p0061 N74 13742
- Design of a military aircraft p0061 N74 13743
- Design of a military aircraft p0061 N74 13744
- Design of a military aircraft p0061 N74 13745
- Design of a military aircraft p0061 N74 13746
- Design of a military aircraft p0061 N74 13747
- Design of a military aircraft p0061 N74 13748
- Design of a military aircraft p0061 N74 13749
- Design of a military aircraft p0061 N74 13750
- Design of a military aircraft p0061 N74 13751
- Design of a military aircraft p0061 N74 13752
- Design of a military aircraft p0061 N74 13753
- Design of a military aircraft p0061 N74 13754
- Design of a military aircraft p0061 N74 13755
- Design of a military aircraft p0061 N74 13756
- Design of a military aircraft p0061 N74 13757
- Design of a military aircraft p0061 N74 13758
- Design of a military aircraft p0061 N74 13759
- Design of a military aircraft p0061 N74 13760
- Design of a military aircraft p0061 N74 13761
- Design of a military aircraft p0061 N74 13762
- Design of a military aircraft p0061 N74 13763
- Design of a military aircraft p0061 N74 13764
- Design of a military aircraft p0061 N74 13765
- Design of a military aircraft p0061 N74 13766
- Design of a military aircraft p0061 N74 13767
- Design of a military aircraft p0061 N74 13768
- Design of a military aircraft p0061 N74 13769
- Design of a military aircraft p0061 N74 13770
- Design of a military aircraft p0061 N74 13771
- Design of a military aircraft p0061 N74 13772
- Design of a military aircraft p0061 N74 13773
- Design of a military aircraft p0061 N74 13774
- Design of a military aircraft p0061 N74 13775
- Design of a military aircraft p0061 N74 13776
- Design of a military aircraft p0061 N74 13777
- Design of a military aircraft p0061 N74 13778
- Design of a military aircraft p0061 N74 13779
- Design of a military aircraft p0061 N74 13780
- Design of a military aircraft p0061 N74 13781
- Design of a military aircraft p0061 N74 13782
- Design of a military aircraft p0061 N74 13783
- Design of a military aircraft p0061 N74 13784
- Design of a military aircraft p0061 N74 13785
- Design of a military aircraft p0061 N74 13786
- Design of a military aircraft p0061 N74 13787
- Design of a military aircraft p0061 N74 13788
- Design of a military aircraft p0061 N74 13789
- Design of a military aircraft p0061 N74 13790
- Design of a military aircraft p0061 N74 13791
- Design of a military aircraft p0061 N74 13792
- Design of a military aircraft p0061 N74 13793
- Design of a military aircraft p0061 N74 13794
- Design of a military aircraft p0061 N74 13795
- Design of a military aircraft p0061 N74 13796
- Design of a military aircraft p0061 N74 13797
- Design of a military aircraft p0061 N74 13798
- Design of a military aircraft p0061 N74 13799
- Design of a military aircraft p0061 N74 13800
- Design of a military aircraft p0061 N74 13801
- Design of a military aircraft p0061 N74 13802
- Design of a military aircraft p0061 N74 13803
- Design of a military aircraft p0061 N74 13804
- Design of a military aircraft p0061 N74 13805
- Design of a military aircraft p0061 N74 13806
- Design of a military aircraft p0061 N74 13807
- Design of a military aircraft p0061 N74 13808
- Design of a military aircraft p0061 N74 13809
- Design of a military aircraft p0061 N74 13810
- Design of a military aircraft p0061 N74 13811
- Design of a military aircraft p0061 N74 13812
- Design of a military aircraft p0061 N74 13813
- Design of a military aircraft p0061 N74 13814
- Design of a military aircraft p0061 N74 13815
- Design of a military aircraft p0061 N74 13816
- Design of a military aircraft p0061 N74 13817
- Design of a military aircraft p0061 N74 13818
- Design of a military aircraft p0061 N74 13819
- Design of a military aircraft p0061 N74 13820
- Design of a military aircraft p0061 N74 13821
- Design of a military aircraft p0061 N74 13822
- Design of a military aircraft p0061 N74 13823
- Design of a military aircraft p0061 N74 13824
- Design of a military aircraft p0061 N74 13825
- Design of a military aircraft p0061 N74 13826
- Design of a military aircraft p0061 N74 13827
- Design of a military aircraft p0061 N74 13828
- Design of a military aircraft p0061 N74 13829
- Design of a military aircraft p0061 N74 13830
- Design of a military aircraft p0061 N74 13831
- Design of a military aircraft p0061 N74 13832
- Design of a military aircraft p0061 N74 13833
- Design of a military aircraft p0061 N74 13834
- Design of a military aircraft p0061 N74 13835
- Design of a military aircraft p0061 N74 13836
- Design of a military aircraft p0061 N74 13837
- Design of a military aircraft p0061 N74 13838
- Design of a military aircraft p0061 N74 13839
- Design of a military aircraft p0061 N74 13840
- Design of a military aircraft p0061 N74 13841
- Design of a military aircraft p0061 N74 13842
- Design of a military aircraft p0061 N74 13843
- Design of a military aircraft p0061 N74 13844
- Design of a military aircraft p0061 N74 13845
- Design of a military aircraft p0061 N74 13846
- Design of a military aircraft p0061 N74 13847
- Design of a military aircraft p0061 N74 13848
- Design of a military aircraft p0061 N74 13849
- Design of a military aircraft p0061 N74 13850
- Design of a military aircraft p0061 N74 13851
- Design of a military aircraft p0061 N74 13852
- Design of a military aircraft p0061 N74 13853
- Design of a military aircraft p0061 N74 13854
- Design of a military aircraft p0061 N74 13855
- Design of a military aircraft p0061 N74 13856
- Design of a military aircraft p0061 N74 13857
- Design of a military aircraft p0061 N74 13858
- Design of a military aircraft p0061 N74 13859
- Design of a military aircraft p0061 N74 13860
- Design of a military aircraft p0061 N74 13861
- Design of a military aircraft p0061 N74 13862
- Design of a military aircraft p0061 N74 13863
- Design of a military aircraft p0061 N74 13864
- Design of a military aircraft p0061 N74 13865
- Design of a military aircraft p0061 N74 13866
- Design of a military aircraft p0061 N74 13867
- Design of a military aircraft p0061 N74 13868
- Design of a military aircraft p0061 N74 13869
- Design of a military aircraft p0061 N74 13870
- Design of a military aircraft p0061 N74 13871



## MISSILE CONFIGURATIONS

### MISSILE CONFIGURATIONS

- Small tactical missiles for 1980 and beyond: Volume 1: Summary p0306 N74 73503  
[AGARD AR 57:1 VOL 1] p0306 N74 73503  
Small tactical missiles for 1980 and beyond: Volume 2: Executive summary p0307 N74 73504  
[AGARD AR 57 VOL 2] p0307 N74 73504  
Small tactical missiles for 1980 and beyond: Volume 3: Numerical analysis of downwash interference on wings of missile tails p0002 N71 19360  
Angle of attack effects on induced rolling moment of low aspect ratio missile at transonic speed p0002 N71 19363

### MISSILE CONTROL

- Techniques for control and guidance of tactical missiles with emphasis on cost, reliability and performance [AGARD LS 52] p0226 N72 27681  
Application of control system requirements to development of tactical missile weapon systems p0226 N72 27683  
Numerical analysis of adjoint equations yielding error sensitivities in linear systems applied to guidance and control of tactical missiles p0226 N72 27684  
Optimizing linear system against quadratic cost function and application to guidance and control system for tactical missiles p0226 N72 27685  
Development and application of Kalman filter techniques to guidance and control of tactical missiles p0226 N72 27686  
Analysis of digital and analog computer techniques for simulation of missile guidance and control and application of hybrid simulation procedures p0226 N72 27687  
Characteristics of electro-optical terminal guidance systems: area correlators and gated trackers used for guidance and control of tactical missiles p0227 N72 27688  
Application of guidance laws to control and guidance of tactical missiles to reduce amount of miss distance p0227 N72 27689  
Terminal guidance systems: comparisons and technology applied to control and guidance of tactical missiles p0227 N72 27690  
Terminal guidance techniques for midcourse guidance and terminal guidance systems with application to control and guidance of tactical stand-off missiles p0227 N72 27691  
Characteristics of command to line of sight guidance and semi-active homing missile systems applied to guidance and control of tactical missiles p0227 N72 27692  
Application of microwave guidance sensors for tracking and fire control systems used in missile attack on small target aircraft p0227 N72 27693  
Role of simulations in the study and development of the CRDARE system: ground to air close defense weapon system p0237 N74 14355  
Terminal guidance system testing: based on conductive tests and verification by limited live firing to increase test cost effectiveness p0237 N74 14356

### MISSILE DESIGN

- Small tactical missiles for 1980 and beyond: Volume 1: Summary [AGARD AR 57:1 VOL 1] p0306 N74 73503  
Techniques for control and guidance of tactical missiles with emphasis on cost, reliability and performance [AGARD LS 52] p0226 N72 27681  
Mission requirements for air-to-air missile and digital computer program to synthesize requirements into preliminary design p0226 N72 27682  
Application of control system requirements to development of tactical missile weapon systems p0226 N72 27683  
Numerical analysis of adjoint equations yielding error sensitivities in linear systems applied to guidance and control of tactical missiles p0226 N72 27684  
Optimizing linear system against quadratic cost function and application to guidance and control system for tactical missiles p0226 N72 27685  
Development and application of Kalman filter techniques to guidance and control of tactical missiles p0226 N72 27686  
Analysis of digital and analog computer techniques for simulation of missile guidance and control and application of hybrid simulation procedures p0226 N72 27687  
Characteristics of electro-optical terminal guidance systems: area correlators and gated trackers used for guidance and control of tactical missiles p0227 N72 27688  
Application of guidance laws to control and guidance of tactical missiles to reduce amount of miss distance p0227 N72 27689  
Terminal guidance systems: comparisons and technology applied to control and guidance of tactical missiles p0227 N72 27690  
Terminal guidance techniques for midcourse guidance and terminal guidance systems with application to control and guidance of tactical stand-off missiles p0227 N72 27691  
Characteristics of command to line of sight guidance and semi-active homing missile systems applied to guidance and control of tactical missiles p0227 N72 27692

### MISSILE SIMULATORS

- Techniques for control and guidance of tactical missiles with emphasis on cost, reliability and performance [AGARD LS 52] p0226 N72 27681

### MISSION PLANNING

- Relationship between mission requirements of piloted aircraft stability and maneuverability p0044 N73 16995

### MIXING LENGTH FLOW THEORY

- Characteristic scales and mixing length methods for determining turbulent boundary layers with mass transfer p0180 N72 20304

### MODAL RESPONSE

- Mathematical modeling of aircraft structural response modes to active control system p0007 N71 27212

### MODELS

- Models for head injury prediction and helmets and prediction of optimum helmet performance p0104 N72 19161

### MODULATION

- Application of chip modulation to improve effectiveness of satellite to aircraft communication p0194 N72 19514

### MODULUS OF ELASTICITY

- Extensometric measurements of elastic modulus on resin fiber composite materials p0207 N72 12455

### MOLECULAR STRUCTURE

- Computer-aided input of graphic information on chemical structures by keyboarding under visual control of display device p0153 N72 22170

### MOMENTUM

- Bursts and streamwise momentum defects in wall region and turbulent boundary layer p0175 N72 20277

### MONKEYS

- Age and exercise factors of learning osteoporect bone strength and ankle strain tolerance investigated using rhesus monkeys [AMRL TR 70 74] p0068 N71 20359

- Noninvasive radiographic observations of spinal fracture and articular facet derangement patterns in rhesus monkeys [AMRL TR 71 115] p0111 N72 19139

- Advantages of breeding Rhesus monkeys in compounds for biomedical research p0083 N73 23063

### MONTE CARLO METHOD

- Monte Carlo simulation of error probability distribution in sensing systems caused by refractive index of sensed medium p0125 N72 16115  
Monte Carlo simulation of random target sequencing considering performance degradation p0280 N73 23899

### MORPHOLOGY

- Inorganic and morphological statistics of solar-station conditions: emphasizing two streamer plasma instabilities p0130 N72 21148

### MORTALITY

- Weather factors: failure of transport aircraft accidents p0030 N71 23401  
Lethal head injury to man swimming upside down: a study by detonation of live rocket p0100 N72 19135

### MOTION SICKNESS

- Development of theory concerning human responses to whole body motion and explanation of spatial illusion and motion effects p0072 N72 25044  
Combined stress effects of human motion sickness and motion sickness symptoms p0104 N73 19 44  
Predictability of motion sickness in pilot selection conferences [AGARD CP 109] p0078 N73 21092

- Three different bases for susceptibility predictions to motion sickness p0078 N73 21093

- Clinical procedures for selecting pilot personnel based on predicted motion sickness scores p0078 N73 21094  
Anticipation and adaptation factors affecting motion sickness susceptibility in pilots p0078 N73 21095  
Real time assessment of vestibular dysfunction in space flight crew members using visual displays and tasks p0078 N73 21096

- Motion sickness questionnaire and flight wide deployment as predictors of success in Navy aviation training p0079 N73 21097

- Brain stimulation: improving standard red complex systems for selection test and rehabilitation of motion sickness patients p0079 N73 21098

- Physiological effects of prolonged following studies in pilots in Belgium: A study for motion sickness p0079 N73 21099

- Methodological methods for feedback motion sickness test of pilots in flight simulator p0079 N73 21100

- Self-induced sensory adaptation effects in flight simulator p0079 N73 21101  
Sickness susceptibility prediction: a review of the physiological experiments and clinical observations p0079 N73 21102

### MOTIVATION

- Motivation and its effects on pilot performance: a review of underlying and its effects p0081 N73 23503  
Cross study of effects of stress and motivation on pilot performance p0088 N74 18785

### MOUNTAINS

- Radio Wave Diffraction due to a mountain ridge p0146 N74 13851

### MOUNTING

- Arbitrary force vector field induced by a magnetic field p0146 N74 13851

### MTBF

- Mean time between failures: a review of system analysis p0146 N74 13851

### MULTICHANNEL COMMUNICATION

- The interrelation of propagation effects and design factors for fixed service communications satellite systems p0149 N74 13871

### MULTIPATH TRANSMISSION

- Optimal multiple access systems and tropospheric path parameters for space communications p0115 N71 21421  
Angular diversity propagation paths of spaced antennas in tropospheric transmission scatter link p0118 N71 23459

- Multipath transmission models for predicting signal distortion and intermodulation in tropospheric scatter propagation p0119 N71 23463

- Frequency correlation measurements on multipath tropospheric scatter propagation p0119 N71 23465

- Path loss prediction methods for tropospheric radio scatter propagation links and comparison with performance tests p0120 N71 23469

- Development of Doppler microwave landing system and techniques for eliminating effects of multipath transmission p0234 N73 23706

### MULTIPLEXING

- Analysis of amplitudes and frequencies of signal fading in satellite to aircraft radio links due to multiplexing of radio signals p0194 N72 19509

### MULTISPECTRAL BAND SCANNERS

- Conference on propagation characteristics of microwave infrared and photographic remote sensing systems for pollution detection and sea state roughness measurements [AGARD CP 90 71] p0121 N72 16085

- History and future developments in infrared and multispectral remote sensing devices p0121 N72 16103

- Multispectral remote sensing: infrared and visible regions for planning remote multipoint terrain photographic photography p0124 N72 16109

- Analysis of satellite multispectral image data for forest land use interpretation p0124 N72 16111

### MULTISPECTRAL PHOTOGRAPHY

- Conference on propagation characteristics of microwave infrared and photographic remote sensing systems for pollution detection and sea state roughness measurements [AGARD CP 90 71] p0121 N72 16085

- Antenna remote multispectral photographic infrared and side looking radar sensors for detecting coastal pollution p0121 N72 16087

- Aerial multispectral color photography for remote reconnaissance of body and rocks p0124 N72 16116

## N

### NACELLES

- Wind tunnel test of after body thrust and direction for nacelles with simplified hollow vane effects p0267 N72 16589

### NARCOTICS

- Chromatographic and photometric methods for determining metabolic levels of hypoxic drugs blood plasma and urine of man p0081 N73 21118

### NASA PROGRAMS

- Advanced NASA and OSD technology management: review progress and application to NATO programs for defense and civil use p0302 N73 19668

- NASA programs in life sciences research: an atmospheric environment: emphasizing cardiovascular system p0083 N73 23058

### NAVIER STOKES EQUATION

- Three approximation methods for full Navier-Stokes equations for two and three dimensional steady flow p0181 N72 27296

- Nonstationary flow of viscous incompressible fluid in two-dimensional p0181 N72 27297

- Navier-Stokes equations of viscous compressible flow in bounded domains p0181 N72 27298

- Numerical analysis of Navier-Stokes equations for time dependent incompressible flow p0181 N72 27299

- Advances in numerical fluid dynamics [AGARD LS 64] p0184 N74 22914

- Numerical integration of Navier-Stokes equations p0184 N74 22915

### NAVIGATION AIDS

- Application and operational experience with computerized navigation systems: a military helicopter p0034 N72 11918

- Harmonized aircraft navigation display and computerized processing and display means of changing and selecting coordinates and elements of data superimposed on map p0224 N72 22633

- Antenna application systems using direct view computerized control map CRT and electronic generated map displays p0224 N72 22634

- Integrated SAGE AS-109 and OME vision facilities and a resulting high altitude air traffic p0232 N73 23695

- Design of a navigation system and a computerized map for sea area navigation system and guidance p0232 N73 23697

- Design of a navigation system and a computerized map for sea area navigation system and guidance p0232 N73 23697

- Design of a navigation system and a computerized map for sea area navigation system and guidance p0232 N73 23697

Aircraft inertial system testing and evaluation in the United Kingdom p0237 N74 14352

# NAVIGATION INSTRUMENTS

Autonomous navigation system for SA 330 helicopter and light test methods p0032 N72 11929

Inertial guidance systems components and technology applied to control and guidance of tactical missiles p0227 N72 27890

Development of low cost inertial measurement unit with navigational accuracy performance based on optimum size design of inertial instruments and platform p0228 N73 20690

Development of rapid initialization of inertial navigation system using azimuth wander mechanization p0228 N73 20693

Optimization of integrated navigation systems combining several independent navigation sensors to provide self contained aircraft navigation capability p0229 N73 20694

Characteristics of airborne area navigation equipment and application to air traffic control functions p0233 N73 23698

# NAVIGATION SATELLITES

Selection of computers for satellite based navigation and guidance systems designed for aircraft users p0157 N72 21226

Analysis of North Atlantic air route structure to determine impact of inertial navigation and satellite surveillance of separation reduction p0233 N73 23699

# NAVIGATORS

French school for training navigators p0136 N72 20993

Color aptitude of dyschromatopsia for navigators and pilots p0177 N73 19068

Influence of long duration flight mission on metabolic and endocrine functions of pilots and navigators p0106 N73 19152

# NAVY

New research administration for a physical environment including radiation effects on human personnel p0276 N72 26054

# NERVOUS SYSTEM

Cardiac and cerebral effects of ultra-radiation on rats p0168 N72 20354

# NETWORK ANALYSIS

Man-machine approach toward solving various loading scheduling and network problems p0154 N72 11199

Computer aided design for electronic circuits p0154 N72 11199

# NOISE

Effect of long term exposure on auditory thresholds for detector signals and recovery from temporary threshold shift p0067 N71 20353

Structural vibration and noise effects on man in space operations p0076 N73 17098

Autonomous use in aerospace operations and bioacoustics effects on man p0076 N73 17100

Analysis of helicopter internal and external noise levels for various flight conditions and timing of aircraft speed p0052 N73 22055

Design of low speed wind tunnels with analysis of parameters affecting noise generation p0184 N73 26285

Acoustic reduction of noise levels on human vestibular system and reduction of acceleration and jolts p0072 N72 20338

Measurement for determining noise levels in flight test measuring systems p0195 N73 10456

Autonomous use in aerospace operations and bioacoustics effects on man p0076 N73 17100

Analysis of helicopter internal and external noise levels for various flight conditions and timing of aircraft speed p0052 N73 22055

Design of low speed wind tunnels with analysis of parameters affecting noise generation p0184 N73 26285

Acoustic reduction of noise levels on human vestibular system and reduction of acceleration and jolts p0072 N72 20338

# NIGHT

Air to ground target acquisition with flare illumination p0303 N73 19968

# NIGHT VISION

Applications of night vision technology helicopter night vision p0303 N73 19970

# NITRIC OXIDE

Parameters controlling nitric oxide emissions from gas turbine combustors p0219 N74 14291

A preliminary study on the influence of fuel staging on nitric oxide emissions from gas turbine combustors p0221 N74 14301

# NITRIDES

Borides, carbides, and nitrides of silicon oxidation resistant refractory compounds for use in gas turbines and rocket vehicles p0203 N73 23616

# NITROGEN

Turbulent mixing layer between two different gas streams such as nitrogen and helium p0178 N72 20295

# NITROGEN OXIDES

Reduction of NO formations by premixing p0217 N74 14272

Nitrogen oxides nuclear weapon testing in stratosphere and troposphere p0217 N74 14275

A new analytical technique for continuous NO detection in the range from 0.1 to 5000 PPM p0218 N74 14280

NO formation in fuel rich flames. A study of the influence of the hydrocarbon structure p0219 N74 14287

# NOISE INJURIES

Effects of long term exposure on auditory thresholds for detector signals and recovery from temporary threshold shift p0067 N71 20353

Structural vibration and noise effects on man in space operations p0076 N73 17098

Autonomous use in aerospace operations and bioacoustics effects on man p0076 N73 17100

Analysis of helicopter internal and external noise levels for various flight conditions and timing of aircraft speed p0052 N73 22055

# NOISE PROPAGATION

Design of low speed wind tunnels with analysis of parameters affecting noise generation p0184 N73 26285

# NOISE REDUCTION

Acoustic reduction of noise levels on human vestibular system and reduction of acceleration and jolts p0072 N72 20338

Measurement for determining noise levels in flight test measuring systems p0195 N73 10456

Autonomous use in aerospace operations and bioacoustics effects on man p0076 N73 17100

Analysis of helicopter internal and external noise levels for various flight conditions and timing of aircraft speed p0052 N73 22055

Design of low speed wind tunnels with analysis of parameters affecting noise generation p0184 N73 26285

Acoustic reduction of noise levels on human vestibular system and reduction of acceleration and jolts p0072 N72 20338

Measurement for determining noise levels in flight test measuring systems p0195 N73 10456

Autonomous use in aerospace operations and bioacoustics effects on man p0076 N73 17100

Analysis of helicopter internal and external noise levels for various flight conditions and timing of aircraft speed p0052 N73 22055

Design of low speed wind tunnels with analysis of parameters affecting noise generation p0184 N73 26285

Acoustic reduction of noise levels on human vestibular system and reduction of acceleration and jolts p0072 N72 20338

Ultrasonic radiographic eddy current and acoustic emission techniques for nondestructive tests of carbon fiber reinforced polymers and failure mechanisms p0296 N72 24935

Nondestructive tests applied to quality control of aircrafts made of boron composites p0290 N72 24936

Terminal guidance system testing based on nondestructive tests of fiber optic gyros p0237 N74 14356

# NONLINEAR PROGRAMMING

Reduction of nonlinear programming problems to sequence of linear programming problems p0283 N71 20133

Feasible direction algorithms for solving general nonlinear programming problems p0284 N71 20135

Structural design applications of geometric programming p0283 N74 15601

The estimation of statically indeterminate structures by means of approximate geometric programming p0296 N74 15602

# NONLINEARITY

Application of discriminate function technique to random search in constrained structural optimization problems p0236 N74 1503

North Atlantic Treaty Organization (NATO) North Atlantic Treaty Organization conference on adaptation and accommodation in aerospace medicine p0067 N71 20351

Equipment and facilities for body dynamic research NATO European countries p0095 N71 20343

Consideration by NATO of human wind tunnel requirements for support evaluation of aircraft and aerospace systems during next decade p0175 N71 25073

Inventories of acoustic fatigue test facilities in NATO countries p0172 N71 24253

AGARD report on engine air and reference and wall correction methods for wind tunnel tests p0106 N73 19152

Aerodynamic testing at high Reynolds numbers and transonic speeds NATO p0016 N72 12978

Research and development of NATO countries in high temperature engines of aerospace vehicles p0201 N72 20491

Advanced NASA and DOD technology management meeting and application to NATO programs for defense p0202 N72 15968

Overseas annual report 1970 to the NATO Military Committee p0305 N74 23492

The AGARD chapter p0306 N74 23493

International conference management p0306 N74 23495

Director's annual report to the North Atlantic Military Committee 1971 p0306 N74 23496

AGARD handbook recording AGARD by laws p0306 N74 23497

Highlights AGARD's twentieth anniversary 1952-1972 p0106 N74 23498

Director's annual report to the North Atlantic Military Committee 1972 p0306 N74 23499

Highlights AGARD's progress in 1973 p0306 N74 23500

AGARD's progress in 1973 p0306 N74 23500

AGARD's progress in 1973 p0306 N74 23500

AGARD's progress in 1973 p0306 N74 23500

AGARD's progress in 1973 p0306 N74 23500

AGARD's progress in 1973 p0306 N74 23500

## NUCLEAR EXPLOSIONS

Full scale thrust performance tests of prototype dual stream propelling nozzle p0263 N72 16691  
Augmentor flap wing ducting and augmentor nozzle and noise reduction for jet STOJ aircraft p0264 N72 16698  
[NASA CR 125540] p0264 N72 16698  
Rapid mixing nozzles thrust vector control and thrust augmentation for V-STOL aircraft p0265 N72 16699

### NUCLEAR EXPLOSIONS

Health hazards and efficiency reductions of personnel exposed to simulated nuclear shock waves in protective shelters p0100 N72 19136  
Acoustic gravity wave propagation modes in ionosphere and neutral atmosphere following nuclear explosion [CONTRIB 1799] p0135 N73 14140  
Nuclear source model for generating ionospheric disturbances through acoustic gravity waves p0135 N73 14141  
Infrasound wave generation and atmospheric propagation of gravity acoustic waves p0136 N73 14142  
Hydrodynamic calculations and experimental observations of ionospheric shock front propagation following nuclear explosion p0137 N73 14150  
Acoustic gravity wave effects in traveling ionospheric disturbances following nuclear explosions p0139 N73 14166  
Effects of traveling ionospheric disturbances following nuclear explosion on high frequency band propagation p0139 N73 14167  
Nonlinear propagation and anisotropic coupling of atmospheric waves following nuclear explosion p0140 N73 14168  
F-layer electron density fluctuations and disturbances following nuclear explosion at ionospheric height p0140 N73 14169  
Effects of acoustic gravity waves following nuclear explosion on ionospheric electron density and high frequency communications p0140 N73 14170

### NUCLEAR RESEARCH

Abstracts on microfiche for the retrieval p0161 N74 16937

### NUMERICAL ANALYSIS

Calculation methods for wing body interference drag on supersonic aircraft in stationary or nonstationary flow p0002 N71 19362  
Numerical analysis of aerodynamic loads on wing and tail surfaces with oscillations in steady supersonic and subsonic flow including interference lift [AGARD CP 80-71 Pt 1] p0007 N71 29333  
Numerical method for evaluating discontinuous downwash distribution for steady flow over swept and rectangular wings p0010 N71 29349  
Methods for calculating and predicting wave drag on complex materials p0209 N72 12508  
Numerical techniques for determining flow characteristics of supersonic turbulent boundary layer in adverse pressure gradient p0179 N72 20300  
Development of numerical process for extracting aerodynamic coefficients from flight test data p0336 N72 20991  
Numerical analysis of one, two and three dimensional fluid flow conferences p0181 N72 27293  
[AGARD LS 48] p0181 N72 27293  
Mathematical aspects of fluid mechanics and numerical analysis of partial differential equations p0181 N72 27294  
Numerical approximation of non-Cauchy-Kowalewski systems in hydrodynamics p0181 N72 27295  
Numerical analysis of Navier-Stokes equations for free dependent turbulent fluid flow p0181 N72 27299  
Numerical analysis of viscous gas flow and shock formation p0181 N72 27300  
Computation of one dimensional shocklet flow p0181 N72 27301  
Numerical analysis of mixed gas flow into a reacting cylinder and computation of steady subsonic flow p0181 N72 27302  
Extension of time dependent technique for mixed fluid body flow to viscous flow p0182 N72 27303  
Numerical analysis of time dependent gas dynamics and accuracy in regions of nonuniform flow p0182 N72 27304  
Computation of transonic mixed flow with embedded shock waves p0182 N72 27306  
Numerical analysis of three dimensional deal gas flow and Euler equations of motion p0182 N72 27307  
Computational and analytical determination of RCS p0144 N74 11956  
Advances in numerical fluid dynamics p0184 N74 22914  
[AGARD LS 64] p0184 N74 22914

### NUMERICAL CONTROL

Numerical control of delta modulated vocal signals in a navigational information system p0131 N73 10194

### NUMERICAL INTEGRATION

Numerical integration of Navier-Stokes equations p0195 N74 22917

### NUMERICAL WEATHER FORECASTING

Turbulence at medium and high flight levels numerical forecasting techniques for clear air turbulence p0057 N74 17771

### NYSTAGMUS

Procedure for determining cases of nystagmus patterns based on postrotational latencies p0012 N72 25019  
Atrophied postrotational latencies in nystagmus and detection of atrophied postrotational latencies p0015 N72 25062

The use of nystagmography in aviation medicine aerospace medicine meeting on nystagmus [AGARD CP 128] p0107 N74 20732

Clinical application of nystagmography in diagnosis of human nervous system pathology p0108 N74 20733  
Practical problems in clinical nystagmography 1. Guidelines for selection of equipment facility for vestibular tests p0108 N74 20734  
Practical problems in clinical nystagmography 2. Sources of error p0108 N74 20735  
Use of nystagmography in the study of a crew with spatial disorientation oculogravic testing of flight crews p0108 N74 20736  
Interest of nystagmography in flying navigation personnel p0108 N74 20738  
A contribution to the electronystagmographic method concerning the interpretation of nystagmus characteristics vestibular tests to assess motion sickness and disorientation susceptibility p0108 N74 20739  
Differential diagnosis of the caloric nystagmus qualitative characteristics of labyrinthine or CNS abnormalities p0108 N74 20740  
Nystagmography A useful tool in basic and applied investigations of human vestibuloculomotor system p0108 N74 20741  
Optokinetic nystagmus Its value in the diagnosis of certain vestibular disorders human abnormal nystagmographic responses in the presence of brain stem lesions p0109 N74 20742  
Visual vestibular interaction The role of the labyrinth in the production of optokinetic nystagmus and optokinetic after nystagmus effects of labyrinthectomy on eye movements in optokinetic tracking task p0109 N74 20743  
Self-motion sensation pseudo stimuli effects on motion sickness induced by optokinetic stimuli psychophysiological experiments on human motion perception p0109 N74 20744  
Normal limits for the sequential bilateral caloric caloric test p0109 N74 20746  
Thermoelectric stimulation of the labyrinth by Peltier regulated miniature plates p0109 N74 20748  
Computerized nystagmography in evaluating the influence of psychopharmacological drugs on nystagmus p0109 N74 20749  
Aeromedical research clinical applications of averaging techniques in nystagmography computer techniques for precise measurements of average eye movements p0110 N74 20750  
Automated nystagmus analysis on line computer technique for eye data processing p0110 N74 20751  
A model for the prediction of the nystagmus response to angular and linear acceleration stimuli mechanism of saccadic generation in vestibulo-ocular reflex p0110 N74 20752  
Vertigo in diving p0110 N74 20753  
Effects of compressed middle ear pressure on the vestibular system in human vertigo due to pressure changes in Eustachian tubes p0110 N74 20755

## O

### OAO

OAO pointing and attitude sensors [NASA TM X 67384] p0277 N72 12863

### OCEAN SURFACE

Damping of gravity wave propagation on the ocean surface p0115 N73 21427  
Ray tracing analysis of duct effect in case of light wave propagation above sea surface p0116 N73 21428  
Atmospheric stratification effects on anomalous signal propagation at 170 and 15000 MHz over sea surface beyond horizon p0116 N73 21429  
Boundary layer theory and meteorological parameters for radar range prediction over sea surface p0121 N73 25474  
Remote sensing of ocean surface effects and formation of sea clutter models p0127 N72 16096  
Error correction procedures for radars on cluttered sea surface temperature measurements p0124 N72 16105  
Error sources in sea surface temperature measurements by satellite borne scanning radiometer p0124 N72 16107  
A study of radar backscatter from the sea detection properties of materials and stand range radar measurements p0126 N72 16119  
Predictions of radar backscatter for magnetic and topographic properties of sea water for application to surface and subsurface remote sensing and visibility p0241 N73 13619  
[AGARD LS 61] p0241 N73 13619  
Explanation of very low level flight levels in case of light paths over sea due to meteorological conditions p0148 N74 13868

### OCULOGRAVIC ILLUSIONS

Use of nystagmography in the study of aircrew with spatial disorientation in oculogravic testing of flight crews p0108 N74 20735  
Self-induced atrophied postrotational latencies and nystagmus in a flight simulator study psychophysiological experiments on human motion perception p0109 N74 20744  
Vertigo in diving p0110 N74 20753

## OMEGA NAVIGATION SYSTEM

Application of a binocular computer in Joran C D and Omega navigation and guidance systems p0151 N72 21225  
Characteristics of airborne navigation equipment and application in a traffic control system p0233 N73 23698

### ON LINE PROGRAMMING

Heuristic on line closure processing training and recognition system p0151 N72 21180  
On line computer technique for evaluating reconnaissance image compression algorithms p0131 N73 10191

### ONBOARD EQUIPMENT

Characteristics of alt-de control system a d on board computer used with ANS astronomical satellite for navigation and X-ray measurements in space p0191 N72 19491

### ONE DIMENSIONAL FLOW

Computation of one dimensional shocked flow p0181 N72 27301

### OPERATING TEMPERATURE

Aerodynamic and thermodynamic performance of swirl cooled gas turbine engine blades p0258 N71 17387  
Temperature field measurements within convective cooled turbine blade of gas turbine engine p0259 N71 17387

### OPERATIONAL PROBLEMS

Technological aspects of flight testing for blades in high temperature gas turbines p0261 N71 17404  
Methods for solving engine airframe interference and wall curvature in transonic wind tunnel tests for predicting aerodynamic performance of airplane design p0014 N72 11877  
Problems of brain and information services to large research center p0158 N73 24204

### OPERATIONS RESEARCH

Accident investigations flight control systems and operational recordings for improved aircraft flight mechanics [AGARD CP 76-71] p0027 N71 23410  
Design concept operational performance and military employment of AV-8A Harrier aircraft p0054 N71 27005

### OPERATOR PERFORMANCE

Measurement of human operator performance in single axis tracking task during simulated turbulent conditions p0040 N72 32034  
The application of aircrew opinions of cockpit tasks and equipment to flight safety research p0107 N74 18802

### OPERATORS (PERSONNEL)

Selfies codes for operators in a flight simulator p0076 N72 16057  
Education and technical training for technical information p0160 N74 16931

### OPHTHALMODYNAMOMETRY

Ophthalmological symptoms of diabetes flying simulator p0086 N74 17198

### OPHTHALMOLOGY

Ophthalmological reasons for grounding pilots of German Air Force p0097 N72 14108  
Ophthalmology of minimal ocular adaptation drugs effects on performance of navigation personnel p0082 N73 21122

### OPTICAL CORRECTION PROCEDURE

Automatic approach and landing system with flash warning signal for Caravelle aircraft control p0030 N73 23429

### OPTICAL DATA PROCESSING

Heuristic on line picture processing training and recognition system p0151 N72 21180  
Edge detection algorithms two dimensional Fourier transforms and requirements for image processing of scanned images p0060 N72 11986  
Method for automatic recognition and classification of three dimensional objects by their subimages p0152 N72 21188  
Optical processing as a method for image processing pattern information by feature extraction p0154 N72 21195  
Image processing and pattern recognition system for image variant images using TV cameras and main computer p0154 N72 21196  
Principles of the optical processing for storage of information in sea clutter systems p0154 N72 21197  
Internal image processing for handling of video data and applications to pattern recognition and optical information p0154 N72 21198  
Digital filtering techniques for line images with pattern recognition p0155 N72 21204  
Detecting boundaries of objects in a sea clutter p0155 N72 21205

### OPTICAL EQUIPMENT

Selfies codes for operators in a flight simulator p0076 N72 16057  
[NASA TM X 66954] p0076 N72 16057  
Comparison of commercial television night vision systems to show advantages of camera night vision systems p0199 N72 25497  
Method of image processing for detection and discrimination of targets in a night vision system p0242 N73 13634  
Characteristics of a night vision system for detection and discrimination of targets in a night vision system p0242 N73 13635  
Techniques for image processing in a night vision system p0242 N73 13636  
Range finding in a night vision system p0242 N73 13636



## PEOPLE SATELLITES

- Passive gravity gradient method for stabilization of Eole and People satellites p0278 N72 12867

## PERCEPTION

- Relationship of interaction of impulsiveness and anxiety to perceptual motor performance in human beings p0069 N71 2036\*

## PERFORMANCE

- Mean time between failure as index to system performance p0190 N71 36785  
Performance tests of protective clothing to determine effectiveness against air blast during high speed ejection p0102 N72 19147  
Mathematical models for measuring inertial qualities of spherical gyroscope rotors with electric suspension p0228 N73 2069\*  
Differential method for evaluating performance of nonlinear accelerometers p0231 N73 20715  
Influence of various aerodynamic forces on rectangular wing performance with harmonic movement parallel to sieve flow movement p0050 N73 21043  
Performance of a craft gas turbine components in hot corrosion environments p0201 N73 23599  
Performance and fatigue strength of compressor blades fabricated from carbon fiber composites and boron composite wires p0213 N73 2496

## PERFORMANCE PREDICTION

- Heat transfer prediction for turbine blade design p0257 N71 17374  
Operational design criteria for gas turbine engines p0261 N71 17402  
Finite element computer program for estimating airplane aerodynamic interference p0001 N71 19357  
[NASA TM X 66884] Computerized prediction of aerodynamic lifting characteristics for wing horizontal tail and canard wing configurations [NASA TM X 66886] p0002 N71 19361  
Statistical prediction of external store separation characteristics from aircraft p0006 N71 19388  
Tropospheric scatter propagation and prediction of radio transmission characteristics p0117 N71 23451  
[AGARD CP 70 71] Radio attenuation prediction method using stratified atmospheric level indices p0120 N71 23468  
Meteorological effects on tropospheric propagation of radio waves for telecommunication p0120 N71 23470  
Statistical forecast of signal attenuation with tropospheric scatter using meteorological parameters p0120 N71 23471  
Mathematical prediction model for tropospheric radio transmission loss over rough surfaces p0120 N71 23472  
Boundary layer theory and meteorological parameters for radar range prediction over sea surface p0121 N71 23474  
Conclusions and recommendations concerning wind tunnel tests of interaction between engine flow and wake corrections in transonic wind tunnels p0010 N71 36401  
Comparison of responses to questionnaire on engine airframe interference in transonic tests p0011 N71 36402  
Procedure for measuring performance of aircraft fire extinguishing powders p0253 N72 11691  
Transonic wind tunnel testing for predicting flight performance characteristics of aircraft p0013 N72 11865  
Correlation of transonic wind tunnel test data with flight test results on slender wing airplanes for double delta configuration development p0013 N72 11868  
Comparison of wind tunnel and theoretical techniques for determining full scale aerodynamic flight drag factors [NASA TM X 67413] p0013 N72 11869  
Comparison of performance predictions and flight data for optimizing transonic wind tunnel design p0014 N72 11871  
Performance and operational characteristics of high Reynolds number blowdown and shock wave tunnels for transonic model testing p0016 N72 11884  
Methods for calculating and predicting viscoelastic constants of composite materials p0209 N72 12508  
Analysis of methods for predicting aircraft performance and recommendations for computer programs to provide accurate prediction capability p0040 N72 32036  
Aerodynamic configurations of swept wings to improve lift performance at stall in higher range of subsonic speeds p0042 N73 15010  
Predicting flying qualities by wind tunnel tests p0045 N73 17000  
Prediction of aerodynamic engineering effects on stability and control p0045 N73 17006  
Designs and performance predictions for high performance supersonic ejector systems [AGARDGRAPH 163] p0183 N73 17248  
Procedure for predicting performance characteristics of second stage diffusers in ejector systems p0183 N73 17250  
Ejector flow model for predicting performance characteristics of supersonic ejector systems p0183 N73 17251  
Development of method for analyzing performance of magnetohydrodynamic generator based on thermodynamic properties and flow characteristics p0010 N73 19051  
Color vision tests as predictive indicators of flying task performance p0078 N73 19074  
Mathematical models for measuring operating methods and performance of gyroscope with two degrees of freedom p0229 N73 20695

- Methods employed to obtain datum position and velocity information for evaluation of inertial navigation systems and identification of error sources p0232 N73 20716

- Analysis of factors inhibiting performance of rotary wing aircraft and mathematical models of rotary wing flow characteristics p0047 N73 21019

- Development of method for predicting performance of heavily loaded propellers and rotors in steady hovering flight p0050 N73 21040

- Development of algorithm for calculating inviscid flow about arbitrary planform rotors and application to analyzing various rotary wing configurations p0051 N73 21048

- Three different bases for susceptibility prediction to motion sickness p0078 N73 21093

- Motion sickness questionnaire and flight independence scores as predictors of success in Naval aviation training p0079 N73 21097

- Alcohol reference method for predicting drug modifications of central nervous system activity and pilot performance decrease p0081 N73 21112

- Exponential probability distribution analysis for extrapolating aerospace system performance statistics from test results p0281 N73 23903

- Development and application of aircraft performance prediction methods for subsonic and supersonic transport [AGARD LS 56] p0052 N73 24042

- Numerical methods for determining range and radius of action performance of transport and combat aircraft and effects of various parameters on performance p0052 N73 24043

- Methods for evaluating and predicting a field performance of turbojet and turbofan aircraft operating in conventional and short takeoff modes p0053 N73 24044

- Development of methods for predicting aircraft flight maneuver and climb performance to show effects of excess power and load factor p0053 N73 24045

- Analysis of parameters affecting choice of engines for transport and combat aircraft during design process p0053 N73 24048

- Development of computer program for determining maximum turn trajectory and comparison with gradient method of computation p0053 N73 24051

- Use of differential phase and gain for predicting performance of ultrahigh frequency telecommunication system p0141 N73 26132

- On the prediction of aerodynamic loads on oscillating wings in random flow [AGARD R 612] p0073 N74 10053

- Full scale fatigue requirements for national fatigue life prediction p0061 N74 19657

## PERFORMANCE TESTS

- Performance of aluminum coatings in simulated high temperature tests on gas turbine engine inlet [NASA CR 116374] p0259 N71 17393

- Flight simulator and airframe test stand for evaluating operational performance of aircraft flight control system p0027 N71 23413

- Operational performance of automatic V-STOL flight control systems using jet thrust of an ejector p0028 N71 23415

- Operational performance and handling safety requirements for single engine boundary layer controlled aircraft in STOL mode p0028 N71 23419

- Flight safety performance of V-STOL Harrier military aircraft having jet control p0029 N71 3427

- Flight mechanics problems in accident investigation for VJ-101 aircraft p0030 N71 23428

- Transonic performance of double flux engine nacelle air intake and afterbody at high Reynolds numbers p0013 N72 11866

- Comparison between conventional flow, laminar and turbulent flow driven transonic wind tunnels for high Reynolds number range p0015 N72 11881

- Performance characteristics of high Reynolds number tube wind tunnel [NASA TM X 67419] p0015 N72 11882

- Full scale thrust performance tests of prototype dual stream propelling nozzle p0263 N72 16691

- Development of techniques for evaluating performance of air breathing engines and measurement of significant operating parameters [NASA TM X 68305] p0035 N72 20983

- Flight tests to determine suitability of aircraft for operation in bright light p0035 N72 20988

- Methods for conducting acceptance tests and reliability tests of gyros as part of a platform quality control procedures p0228 N73 20689

- Laboratory tests of accelerometers used in inertial guidance systems as flight simulator programs p0231 N73 20714

- Evaluation of helicopter handling qualities based on ground based flight simulator tests p0049 N71 20039

- Performance tests of aircraft control system to determine effectiveness in prevention of stall conditions p0035 N73 20713

- PIVA Acceleration tests on vertical takeoff and landing aircraft and on tests of inertial guidance systems p0236 N74 14347

- Flight guidance system reliability testing development and characteristics of test equipment p0236 N74 14348

- Trends towards standardized software and hardware for test systems based on process computer with interface unit and input/output peripherals p0236 N74 14351

- Inertial guidance system sled testing p0237 N74 14354

- Terminal guidance system testing based on conductive tests and verification by limited live firing to increase test cost effectiveness p0237 N74 14356

- Some considerations of future low speed tunnels for Europe p0173 N74 16988

## PERIPHERAL VISION

- Peripheral acuity with complex stimuli at two viewing distances p0303 N73 19965

## PERSONALITY TESTS

- Personality traits and flight aptitude p0089 N74 18789

## PERSONNEL

- Navy research and instrumentation for analyzing noncognitive and action effects on human personnel p0076 N72 26054

## PERSONNEL SELECTION

- Predictability of motion sickness in pilot selection conferences p0078 N73 21092

- Reaction assessment of vestibular dysfunction stress for aircrew selection using visual displays and tasks p0079 N73 21096

- Curriculum development and personnel training for information centers p0158 N73 24205

## PERTURBATION

- Complex turbulent flows as perturbations of classical thin shear layers and application of Prandtl approximation p0175 N72 20274

## PH

- Microelectrodes for measuring pH gradients during stress corrosion of aluminum alloys and 1020 steel exposed to potassium chloride p0286 N73 26109

## PHARMACOLOGY

- Effects of ethanol and pharmacokinetics on adaptability of human beings to degraded sensorial environments p0069 N71 20364

## PHASE CONTROL

- Attenuation and phase constant propagation criteria of tactical satellite communications using mobile ground terminals p0132 N73 10201

## PHASE DEMODULATORS

- Digital receiver for detecting moderate data rate phase shift keyed signals in real time p0132 N73 10196

## PHASE DEVIATION

- Water evaporation interference in phase measurements by transhorizon microwave propagation over sea surface p0140 N73 26125

- Attenuation and phase dispersion of radio wave in atmosphere due to oxygen microwave spectrum p0141 N73 26126

## PHASE MODULATION

- Interchannel interference and Gaussian noise effects on phase modulated digital microwave radio systems p0134 N73 10211

## PHASE SHIFT

- Ultrahigh frequency coherent radio signal transmission for differential phase shift measurements due to vapor and oxygen absorption lines p0141 N73 26131

- Use of differential phase and gain for predicting performance of ultrahigh frequency telecommunication system p0141 N73 26132

## PHENOLIC RESINS

- Ultrasonic measurements of silica epoxy and silica phenolic sheets in liquid fuel tanks p0207 N72 12494

- Physical and mechanical properties of high strength high modulus reinforcing fibers and organic resin composite materials p0210 N72 23475

## PHOTOCHEMICAL REACTIONS

- Reaction of ozone with nitrogen oxides in high altitude p0217 N74 14214

- Photooxidation of aircraft engine emissions at low and high altitudes p0218 N74 14217

- Effect of supersonic transport upon the ozone layer studied in a two dimensional photochemical model with transport p0218 N74 14278

## PHOTODISSOCIATION

- Chemical kinetics in the stratosphere: atmospheric composition and atmospheric chemistry base for photochemical reactions p0218 N74 14279

## PHOTOELECTRICITY

- Method for comparing photoelectric and photodiode detectors based on product of signal to noise ratio times spatial bandwidth p0242 N73 33634

- Techniques for long range vision underwater using range gating and dual scans with parallel technique p0242 N73 33636

## PHOTOGRAPHIC EQUIPMENT

- Methods and developing systems: A state of the art review p0160 N74 14932

## PHOTOGRAPHIC MEASUREMENT

- Laser photogram technique for measuring spatial and depth of passive states in turbulent wake p0119 N72 20297

## PHOTOGRAPHIC RECORDING

- Mathematical models for mechanical analysis of mechanical systems used in photogrammetric systems p0199 N72 21496

- Principles for photographic and mathematical methods of recording the interaction between a laser beam and reflected light waves p0199 N72 21499

**PILOTS**

Predictions and measurement of multi-channel prior performance and system design implications for prior capability and limitations. 00333 5.23 22625

Environ Monit Assess (2008) 142:111–121

[NASA CR 126255] p0223-572-226-7

Contribution of reduced visibility and turbulence to loss of aircraft control and inadvertent aircraft maneuvers.

[illegible]

Analysis of aircraft pilot reports on disorientation during flight and relations<sup>1</sup> to spatial disorientation  
 p0072 572 25042

Development of schematic representation of pilot workload and functions for various portions of a combat flight and reaction to various stimuli. p0040 N72 32035

## Conceptual model for post war

Measurements of accelerational stress effects on pilot  
maneuvering ability and flight control performance  
LAMPSON, R. G., JR. 1968, p. 20-21.

By a theorem of H. Cartan, the

05080 473 21103

Under the terms of the agreement,

Polyphasic and sleep patterns during duration

 $\log_{10}(1 + 3.00 \times 10^{-4})$  and  $\log_{10}(1 + 1.00 \times 10^{-4})$  are

**Aids:** five tracking task for evaluating pre- and after effects  
of hand force performance. (PC80 N73 21109)

Effect of social treatment on pilot performance

Also, the telephone number is:

At short latencies performance degradation in older

Simulation of profile von Mises process on a  
lattice generated by  $\lambda = 0.280547323898$

Mathematics 2020, 8, 506

considering poor performance degradation  
p0280 473 23899  
Activities of 2nd Air Streetcar units in operational flight

[ABSTRACT 508] (0005 443 2789)

M. V. and J. A. have been a full-time family enterprise to carbon monoxide effects of tobacco on oral cavity cancer.

Dr. M. V. and Dr. J. A. are currently working on a project to develop a new method for measuring the effect of tobacco on oral cavity cancer.

Medical and physiological development and mental requirements in raised flight. **0808 574 18280**

In light of the load on students' parts, evaluated by means of Van Manstein, Acid (DMA) changes, primary aspect:

Part 13: *How to find the area of a circle*

**PILOT SELECTION**  
On a per cent basis, the selection of pilot personnel is based on a combination of factors. The following is a list of factors: 038 1-12 2100

Please direct all mail to:  
Belgian Air Force Headquarters  
0973 573 21099

Inter-University report concerning the degree of  
inter-university standards for the purpose of  
the study.

Received: 24 November 2009; revised: 22 February 2010; accepted: 22 February 2010  
Published online: 27 February 2010

Aspirin 0.6 g daily, 1978-1980  
Sedation with diazepam 1 mg/kg  
Exposure to gas by inhalation 1978

1978 1979 1980  
1985 1974 13797  
1988 1974 18788

Deposited by the depositor

[illegible]

Journal of Interpersonal Violence 24(12) 2009 2009 Sage Publications  
10.1177/0886260509348214  
http://jiv.sagepub.com  
DOI: 10.1177/0886260509348214  
http://jiv.sagepub.com at 11/11/2009

PILOT TRAINING  
 5 months of operation of US A-10 in Iraq  
 1991-1992-1994

[illegible]

© 1994 by John Wiley & Sons, Inc. All rights reserved. Printed in the United States of America. This book is registered at the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923.

[illegible]

Manuscript received 12 May 1993  
Manuscript accepted 12 September 1993  
© 1994 by the American Society of Limnology and Oceanography

## PILOTS

A-51

1000

1000

1000

## PILOTS (PERSONNEL)

### PILOTS (PERSONNEL)

Role of flight surgeon and physician pilot in evaluation and treatment of jet fighter pilots. p0055 N72 14094  
Physiological factors possibly contributing to coronary risk among German Air Force pilots. p0097 N72 14104  
Optimal physiological reasons for grounding pilots of German Air Force. p0097 N72 14108  
Psychological factors in pilot grounding in German Air Force. p0098 N72 14111  
Radiological observations of spinal injuries in pilots caused by sudden ejection. p0102 N72 19148  
Color aptitude of dyschromatopsia French navigators and pilots. p0077 N73 19068  
Influence of long duration flight missions on metabolic and endocrine functions of pilots and navigators. p0106 N73 19152  
Management of asymptomatic carriers of hepatitis associated antigen in Hellenic Air Force personnel. p0083 N73 23060

Clinical psychology and psychiatry of the aerospace operational environment. conference. p0088 N74 18779  
Fear of flying and its treatment in military pilots. p0088 N74 18781  
Results of behaviour therapy in flying phobia. p0088 N74 18782

Assessment of behaviour therapy in the treatment of flying phobias. p0088 N74 18783  
Partial cerebral hypoxic attacks in pilots as cause of hypoxia incidents. p0088 N74 18786  
Characteristics of life stress in a population of military aviators. p0088 N74 18787  
Influence of social relational factors on operational flying capacity. A system-oriented approach. p0089 N74 18791

**PLAN POSITION INDICATORS**  
Digital filtering procedures for line images with plan position indicators. p0155 N72 11204

**PLASMA CONTROL**  
Application of superconducting magnets for plasma physics experiments and as component for future thermonuclear reactors. p0063 N73 19033

**PLASMA DYNAMICS**  
Analysis of performance of pulsed coaxial guns based on snowplow model allowing for variable initial mass loading distribution. p0066 N73 19057

**PLASMA GENERATORS**  
Application of superconducting magnets for plasma physics experiments and as component for future thermonuclear reactors. p0063 N73 19033

**PLASMA GUNS**  
Analysis of performance of pulsed coaxial guns based on snowplow model allowing for variable initial mass loading distribution. p0066 N73 19057

**PLASMA JETS**  
Analysis of performance of pulsed coaxial guns based on snowplow model allowing for variable initial mass loading distribution. p0066 N73 19057

**PLASMA PHYSICS**  
Development of optical stratons and Doppler spectrum broadening due to barium plasmas in ionosphere. p0128 N72 21136

**PLASMA TURBULENCE**  
Theoretical plasma perturbation model for calculating coupling effects between acoustic gravity waves and electromagnetic waves in ionosphere disturbances. p0138 N72 14162

**PLASMA WAVES**  
Ionograms and ionospheric statistics of polar storm condition emphasizing two stream ion plasma ion wave instability. p0130 N72 21148

**PLASMAS (PHYSICS)**  
Spatial distribution of plasma in polar upper atmosphere based on satellite data. p0126 N72 21124  
Ion acoustic waves in auroral plasma and its wave scattering. p0127 N72 21132

**PLATES (STRUCTURAL MEMBERS)**  
Mechanical properties and stress corrosion of hot rolled alloy plates. p0289 N72 21971  
Analysis of dynamics of stiffened plates using finite element modelling of flat and curved stiffened panels. p0293 N72 29911  
Improvement of the properties of high strength Al-Zn-Mg Co alloys by thermomechanical procedures. ductility, toughness and stress corrosion properties of steel plates and forgings. p0224 N74 23111

**PLATINUM**  
Thermal expansion behavior of platinum Al<sub>2</sub>O<sub>3</sub> tungsten alloys and graphite. [AGARD AR 38] p0293 N72 24969

**PLUGS**  
Thermoelectric stimulation of the labyrinth by Peltier regulated Zener diode plug. p0109 N74 20748

**PLUMES**  
A study of flow separation in the base region and its effects during powered flight. interaction between propulsive and free stream flow. p0202 N74 14774

**PNEUMATIC EQUIPMENT**  
Aerodynamic equipment high lift devices. p0025 N73 20053  
Pneumatic system with 10 safety in electric control system. p0278 N72 12868  
Development of pneumatic power systems for supercritical aircraft based on pneumatic power generators. p0096 N73 19056

### PNEUMOTHORAX

Idiopathic spontaneous pneumothorax in young personnel. p0085 N74 13793

**PODS (EXTERNAL STORES)**  
Technical and operational aspects of externally mounted aircraft equipment. p0305 N74 21617

**POINTING CONTROL SYSTEMS**  
OAO pointing and attitude sensors. [NASA TM X 87384] p0277 N72 12863

**POLAR REGIONS**  
Particle precipitation in polar upper atmosphere. p0126 N72 21122  
Spatial distribution of plasma in polar atmosphere based on satellite data. p0126 N72 21124  
Polar propagation effects on HF radar in auroral and subauroral regions. p0129 N72 21142

**POLARIZATION (WAVES)**  
Radio wave polarization in auroras. p0127 N72 21133  
Debye polarization theory for determining electromagnetic sum of sea surface. p0241 N73 33620

**POLARIZATION CHARACTERISTICS**  
Polarization coupling losses on sky wave paths at high altitude. p0129 N72 21145

**POLARIZED ELECTROMAGNETIC RADIATION**  
Rain depolarization of linearly and circularly polarized microwaves. p0141 N73 26127

**POLYIMIDES**  
Design, fabrication and test of boron polyimide reinforced titanium fan disks to operate at high temperatures. p0213 N73 27493

**POLYMERS**  
Properties and selective applications of thermosetting and thermoplastic polymers. p0205 N71 27042

**POROSITY**  
Age and exercise factors influencing osteoporosis bone strength and acceleration tolerance investigated using rhesus monkeys. [AMRL TR 70 74] p0068 N71 20359

**PORTABLE EQUIPMENT**  
Requirements for using Talar 4 landing aid as portable ground station in tactical helicopter operations. p0032 N72 11925

**POSTURE**  
Posture effects on flight crew tolerance to positive acceleration. p0068 N71 20357

**POTENTIAL FLOW**  
Calculated values of air forces on oscillating thin wings obtained by linearized potential flow. [AGARD R 583 71] p0010 N71 35198

**POWDER (PARTICLES)**  
Procedure for measuring performance of aircraft live testing shrapnel powders. p0253 N72 1691

**POWER AMPLIFIERS**  
Characteristics of solid state power amplifiers for direct amplification using diodes and triodes and application to interplanetary space probes. p0194 N72 19510

Generation of superhigh frequency power using negative impedance characteristics of avalanche diodes in reflection amplifiers. p0195 N72 19511

**POWER EFFICIENCY**  
Production and efficiency of small gas turbine engine for helicopter and surface vehicles. [AGARD LS 46 71] p0261 N71 26951

Thermodynamic cycle and power output parameters of gas turbine. p0262 N71 26954  
Influence of anabatic air compression on power of hydraulic motors and pumps. p0066 N73 19055

**POWER PLANTS**  
Production and efficiency of small gas turbine engine for helicopter and surface vehicles. [AGARD LS 46 71] p0261 N71 26951

Cross effectiveness as critical selection requirement for small gas turbine in military and commercial operation. p0262 N71 26951  
Thermodynamic properties of small gas turbine engine generation in aeronautics space and industry. p0262 N71 26957

**POWER SPECTRA**  
Power spectrum method for determining stiffness frequency response functions in dynamic aircraft loads. p027 N71 23211

Rational calculation of design gust loads in relation to present and proposed airworthiness requirements. Effects of atmospheric turbulence on sea dynamic configuration of short hull aircraft. p0059 N74 17749

**PRANDTL NUMBER**  
Complex turbulent flows as perturbations of classical thin shear layers and application of Prandtl approximation. p0175 N72 20274

**PRECIPITATION (METEOROLOGICAL)**  
Atmospheric measurement of precipitation rates and radar reflectivity by precipitation microwave frequencies. p0155 N73 21412

Measurements of microwave attenuation by precipitation by ATS 5 satellite bearing. p0115 N73 23419

Precipitation models from radar and satellite data for predicting radar clutter characteristics. p0146 N74 13854

Measurements of precipitation water at 1.6 GHz. Estimating atmospheric humidity from satellite data. p0147 N74 13855  
Precipitation models from radar and satellite data for predicting radar clutter characteristics. p0148 N74 13869

### PRECIPITATION PARTICLE MEASUREMENT

Multipath rainfall measurements for planning ultrahigh frequency radar link. p0142 N73 26137  
Ultrahigh frequency precipitation attenuation measurements by ATS 5 weather radar and radiometer. p0143 N73 26142

### PREDICTION ANALYSIS TECHNIQUES

Development and application of aircraft performance prediction methods for subsonic and supersonic transport and fighter aircraft. [AGARD LS 56] p0052 N73 24042

Development of procedures for predicting fatigue life of aircraft structures based on fracture mechanics crack propagation and residual static strength analysis. [AGARD LS 62] p0294 N71 29924

Development of fatigue life prediction procedures based on measured stress time histories and mathematical model for description of random vibrations. p0294 N73 29926

Effect of environment and stress cycling on in service structural failure of airframes and procedures for predicting safe operational conditions. p0295 N73 29929

Application of growth rate data and analytical retardation models for predicting crack growth under variable amplitude loading. p0295 N73 29932

Analysis of errors in fatigue life prediction procedures and methods for improving accuracy of prediction analysis techniques. p0295 N73 29934

Specialists Meeting on Helicopter Rotor Prediction Methods. [AGARD CP 122] p0055 N74 10908

Prediction of helicopter rotor loads based on altering aerodynamic loads imposed on rotor wing and rotor hub. p0056 N74 10911

Helicopter rotor loads predictions assumptions and techniques for numerical analysis of aerodynamic loads. p0056 N74 10912

Rotor system design and evaluation using a general purpose helicopter flight simulation program. p0056 N74 10913

Integrated rotor body loads prediction. p0057 N74 10916

Introductory survey to session 4. Propagation data interference probability determinations. p0147 N74 17561

A survey of drag prediction techniques applicable to subsonic and transonic aircraft geometry. p0019 N74 14711

Aerodynamic drag and lift of general body shapes at subsonic, transonic and supersonic Mach numbers. p0019 N74 14712

On some basic and new aspects about the drag problem of wings and bodies in supersonic flows. p0019 N74 14713

Aircraft drag prediction for project appraisal and performance estimation. p0019 N74 14716

Appendix A data item service for aircraft drag evaluation collection dissemination and development of aerodynamic drag prediction data. p0020 N74 14717

Remarks on methods for predicting viscous drag aerodynamic drag prediction for high angles of attack and multiple airfoils. p0020 N74 14718

Prediction of buffet onset for aircraft: recent progress in wind tunnel and flight test data correlation. p0021 N74 14725

A model for the prediction of the dynamic response to angular and linear acceleration shock mechanism of sacral operation in vestibular afferents. p0110 N74 20752

### PRESSURE

Physiological responses to internal and external pressure and hypoxia under acute and chronic exposure to ambient P<sub>sub</sub> CO<sub>2</sub> of 21 mm Hg. p0070 N74 20730

### PRESSURE BREATHING

Post hypobaric breathing form increased human arterial blood pressure. p0106 N73 19156

### PRESSURE DISTRIBUTION

Approximation of pressure distribution over wing body configurations at subsonic speeds. p0003 N71 19164

Calculation of pressure distributions over wings with harmonized oscillating control surfaces using kernel function method. p0009 N71 29346

Asymptotic expansion techniques to define pressure loading effects on wings with vibrating control surfaces. p0010 N71 29348

Reynolds number effect on flow past body of revolution at transonic speeds. p0012 N72 11864

Pressure distribution on swept wings for analyzing scale effect at high subsonic speeds. p0013 N72 11867

Heat transfer and pressure distribution rates and point pressure profiles for turbulent boundary layers at subsonic and supersonic speeds. p0179 N72 20251

Application of the large scale flow factors to wind tunnel test measurements of aircraft bodies. p0042 N73 15006

Analysis of aerodynamic processes in the flow past airfoils. p0042 N73 15007

Analysis of surface pressure fluctuations from jet impingement on a flat plate with application to design of aircraft with externally blown flow. p0222 N73 29929

Drag coefficient of a tapered flow affected compressive drag and friction drag. p0021 N74 14739

Strong interference effects on afterburner air pressure. p0022 N74 14737

**PRESSURE EFFECTS**  
Impulse loading method for turbine rotor blades. p0250 N71 12397

## PRESSURE GRADIENTS

- Transformation function for turbulent boundary layers with optional pressure gradient p0176 N72 20278
- Coupling effects between wall heating and axial pressure gradients in turbulent boundary layer flow [NASA CR 125903] p0176 N72 2028
- Model for compressible turbulent boundary layer applicable to flows with pressure gradient and surface mass transfer p0176 N72 20283
- Compressible turbulent boundary layer velocity and temperature profiles with zero pressure gradient p0177 N72 20287
- Streamwise pressure gradient effects on two-dimensional compressible turbulent boundary layers at high Reynolds number p0177 N72 20289
- Effects of adverse pressure gradient on compressible turbulent boundary layer flow p0179 N72 20299
- Numerical techniques for determining flow characteristics of supersonic turbulent boundary layer in adverse pressure gradient p0179 N72 20300
- The drag resulting from three-dimensional separations caused by boundary layer dividers at small angles of attack and supersonic flow p0179 N72 14728

## PRESSURE MEASUREMENTS

- Unsteady pressure measurements on a high speed oscillating swept wing with two control surfaces in incompressible flow p0070 N71 29350
- Development of two experimental approaches for analyzing two-dimensional flow on high speed airfoils p0042 N71 15025
- Comparison of various methods for calculating profile drag from pressure measurements in the wake of airfoils at speeds p0020 N74 14721
- Effects of compressible flow on pressure in the wake of airfoils p0110 N74 20755

## PRESSURE OSCILLATIONS

- Free vibration pressure fluctuations effects on turbulent flow stall characteristics p0037 N72 20027

## PRIMATES

- Three primate species undergoing adaptation studies p0099 N74 19127

## PRINTED CIRCUITS

- Computer aided design of multilayer printed circuit boards p0068 N74 13934
- Optimizing automatic tracking of multilayer boards p0168 N74 13936
- A parallel printed circuit board design p0168 N74 13936

## PROBABILITY THEORY

- Modeling function of probability of target acquisition as a function of its range as target is approached p0002 N73 19962
- Probability of acquiring targets by search aircraft which fly along enemy line of communication p0004 N73 19973

## PROBLEM SOLVING

- Asymptotic expansion techniques to define pressure loading effects on wings with embedded control surfaces p0010 N71 29348
- Numerical method for evaluating lift and drag on wings with distributed flow over smooth and corrugated airfoils p0010 N71 29349
- Main machine approach to forward sweep wing loading, scheduling, and network problems p0154 N72 11199

## PRODUCT DEVELOPMENT

- Computer aided design concepts p0165 N74 13912

## PRODUCTION ENGINEERING

- Engineering aspects and manufacturing of gas turbine engines for helicopters and ground transport vehicles p0262 N71 26951
- Systems analysis for selection and application of materials p0205 N71 20030

## PRODUCTION PLANNING

- Production and efficiency of small gas turbine engine for helicopter and surface vehicles [AGARD LS 46 71] p0261 N71 26951

## PROGRAMMING LANGUAGES

- Algorithmic mathematical computer aided design systems using high level graphical languages p0167 N74 13929
- Specification and design languages for high speed systems p0168 N74 13930

## PROJECT PLANNING

- Project planning for study of engine aircraft interface systems p0253 N72 16686

## PROJECTILES

- Measurement of drag on a shock tunnel p0023 N74 14739

## PROPAGATION MODES

- Acoustic gravity wave propagation modes in atmosphere and ionosphere atmosphere following magnetic equator [ICASE 18 199] p0135 N71 14149

## PROPELLER BLADES

- Markings for propeller components [AGARD LS 45] p0099 N74 19123

## PROPRECEPTION

- Vegetation growing p0110 N74 20753

## PROPULSION

- Engine aircraft interface design, test, nozzles and propulsion systems, review p0263 N72 16685
- Research equipment methods and data analysis Propulsion Test Center, Florida p0263 N72 16690

- Life, engine, and exhaust cycle tests for supersonic propulsion system [NASA TM X 67741] p0263 N72 16692
- Propulsion jet flow for vertical takeoff aircraft p0265 N72 16700

## PROPULSION SYSTEM CONFIGURATIONS

- Design problems of inlets and nozzles and in supersonic and V-STOL propulsion systems [NASA TM X 67741] p0263 N72 21819
- Design parameters and characteristics of intermittent pulse jet engine for use as auxiliary power source p0065 N71 19047

## PROPULSION SYSTEM PERFORMANCE

- Fuel related problems in aircraft fuel systems, emphasizing hydrogen treated fuel p0252 N72 14777
- Feasibility analysis of solid lubricated ball bearings for aircraft propulsion systems application p0255 N72 11710
- Destabilizing factors affecting supersonic jets and turbulent engines of propulsion system p0266 N72 16711
- Analysis of gas turbine engine requirements and performance when main propulsion system furnishes auxiliary power source p0065 N71 19050

## PROTECTION

- Protective aspects of passive extrinsic for vehicles p0103 N72 19156

## PROTECTIVE CLOTHING

- Materials and design of protective clothing p0102 N72 19143
- Performance tests of protective clothing to determine effectiveness against air blast during high speed explosion p0102 N72 19147
- Factors, standards, and techniques involved in testing protective headgear p0104 N72 19163
- Algorithms for protective equipment evaluation and human impact acceleration experienced p0084 N73 23066

## PROTECTIVE COATINGS

- Reflectivity materials with protective coatings for use in structural components of nuclear reactors p0203 N73 23674

## PROTEIN METABOLISM

- Protein metabolism in flying personnel p0087 N74 11802

## PROTOTYPES

- Passive dynamic interpretation of dynamic behavior of rate board flight prototype of C-130 [AGARD LS 58] p0098 N72 26052

## PSYCHIATRY

- Application of psychiatry in aviation psychiatry for treatment of syndromes of reactive nature p0069 N71 20365
- Psychiatric reasons for personnel desertion of flight crew members in Royal Air Force p0098 N72 14119

## PSYCHOACOUSTICS

- Effects of high intensity sound levels on human vestibular system and production of discomfort and nausea [AMRL TR 71 58] p0072 N72 25038

## PSYCHOLOGICAL EFFECTS

- Physiological and psychological limits and ranges of human response to acoustic stimuli p0067 N71 20352
- Physiological and psychological effects of low and high magnetic fields on man p0076 N72 26055
- Analysis of an air traffic controller responses under stress conditions to show effects of auditory quality and comprehensibility of available data p0035 N72 23714

## PSYCHOLOGICAL FACTORS

- Statistical study of psychological factors in ground crew members of fighter aircraft p0095 N72 14091
- Psychological factors in pilot grounding in German Air Force p0098 N72 14119

- Human factors approach to aircraft accident analysis, definition of human errors and potential a way for reducing human error in aircraft accidents p0107 N74 18799

- The human factor in aircraft accident patterns, statistical analysis of CR 104 aircraft accident patterns p0107 N74 18809

- The psychological factors in aircraft accident patterns p0107 N74 18803

## PSYCHOLOGY

- Psychological training for flight crew flying personnel p0098 N72 14112
- Sports medicine parameters necessary for maintaining performance form p0081 N73 21114

## PSYCHOMETRICS

- Use of psychometric tests to select for suitable type variation in operator performance relative to target acquisition p0034 N73 14974
- Selection of test procedures for the Belgian Air Force flying personnel p0088 N74 18788

## PSYCHOMOTOR PERFORMANCE

- Systematic evaluation of display design based on criteria with pilot psychomotor ability [NASA CR 126756] p0223 N72 26227
- Enhanced operator utilization effects of target acquisition and display presentation p0105 N73 19147
- Human performance in a sequential task requiring for a variation of perceptual-motor skills, speed-accuracy trade-off p0116 N73 19153
- Measurements of acceleration, speed, and accuracy in a pilot performance ability and flight simulator performance [AMRL TR 72 3] p0106 N73 19154

## PSYCHOPHYSIOLOGY

- Aging effects on pilot psychophysiological abilities and flying proficiency p0093 N71 22319
- Occurrences of vertigo in hyperbaric atmospheres and among underwater divers with theoretical explanations of etiology involved p0072 N72 15043
- Human stress expenditures in operational and mission flights p0106 N73 19151

## PSYCHOSOMATICS

- Drug therapy effects on flying effectiveness and psychosomatic fitness of flying personnel p0080 N73 21103

## PSYCHOTHERAPY

- Application of psychotherapy in aviation psychiatry for treatment of syndromes of reactive nature p0069 N71 20365
- Physical exercise and environmental emotional psychotherapeutic methods in aerospace medicine p0092 N71 22310

- Aeronautical rehabilitation of flying personnel suffering from acute psychiatric disturbances p0086 N74 13796
- Assessment of behavior therapy in the treatment of flying phobias p0088 N74 18783

## PSYCHOTIC DEPRESSION

- Depression in flight p0088 N74 18784

## PULMONARY FUNCTIONS

- Respiratory gas analyzer for crew pulmonary function measurements [NASA TM X 68370] p0074 N72 25057

## PULSE CODE MODULATION

- Application of complementary MOS technology to pulse code modulation systems for photoammetry of X-ray region of solid angle and in operation of quartz clock with PCM output p0192 N72 19501

- Development of pulse code modulation system for encoding and formatting data using satellite onboard equipment p0193 N72 19503

- Development and operation of programmable PCM telemetry encoder for data storage and processing during space missions p0193 N72 19504

- Noise and error effects in digital pulse code modulation transmission of sampled aerodynamic data p0131 N73 23190

## PULSE COMMUNICATION

- Conference on extended aerospace telecommunication system requirements and digital data transmission methods [AGARD CP 103] p0130 N73 10187

- Interference interference and delays in a multi-channel phase modulated digital microwave radio system p0134 N73 10211

- Processing of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053

- Performance of spread spectrum signals in a multi-channel and application to digital communication systems [AGARD LS 58] p0143 N73 32053



- Nondestructive test for failure inspection and quality control of composite structures and materials conference  
[AGARD R 590] p0290 N72 24834
- Nondestructive tests applied to quality control of air frames made of boron composites p0296 N72 24936
- QUANTUM MECHANICS**  
Wave mechanics theory for assessing remote sensing in atmospheric turbulence with refractivity variations p0125 N72 16116
- QUASI STEADY STATES**  
Development and characteristics of high intensity direct heating heat flux gauge of quasi steady state type  
[ISC DR 710194] p0190 N71 36789

R

- RADAR**  
Cardinal and natural effects of UHF radar energy on frogs p0068 N71 20354  
Characteristics and effects of Arctic ionosphere on radio and radar propagation conference  
[AGARD CP 97] p0126 N72 21121
- Auroral radar network for statistical and single event studies of radio aurora morphology and scattering mechanisms p0127 N72 21127
- Radar aurora studies using backscatter radar p0127 N72 21129
- Radar aurora at frequency of 1295 MHz p0127 N72 21130
- Ionospheric propagation model and application to high latitude HF radar propagation p0130 N72 21153
- RADAR BEACONS**  
HF auroral backscatter scintillation theory and satellite beacon recordings p0130 N72 21150
- RADAR CLUTTER MAPS**  
Remote sensing of ocean surface effects and formulation of sea clutter models p0122 N72 16096
- Radar sea clutter sea state effects on cross sectional echo characteristics p0145 N74 11962
- RADAR CROSS SECTIONS**  
Determination and use of Radar Scattering Characteristics  
[AGARD LS 59] p0143 N74 11954
- Computational and analytical determination of RCS p0144 N74 11956
- Static full scale measurements of RCS p0144 N74 11957
- Dynamic full scale measurement of RCS p0144 N74 11958
- Radar Echoing areas of flying animals p0144 N74 11961
- Radar sea clutter sea state effects on cross sectional echo characteristics p0145 N74 11962
- Presentation and storage of radar cross section data p0145 N74 11964
- The use of RCS data for radar systems design p0145 N74 11966
- State of the art and future prospects p0145 N74 11967
- RADAR DATA**  
Presentation and storage of radar cross section data p0145 N74 11964
- State of the art and future prospects p0145 N74 11967
- RADAR DETECTION**  
Radar observations of meteor trails for detecting high altitude gravity waves p0137 N73 14154
- RADAR ECHOES**  
Airborne measurements of radar attenuation and radar reflectivity by precipitation by microwave frequencies p0115 N71 21417
- Airborne remote radar sensor for depth sounding in Antarctica p0123 N72 16099
- Matrix method for calculating adaptive prewhitening filter for radar echo signal processing p0132 N73 10197
- Detection of tropospheric turbulence and gravitational waves by radar sounding p0137 N73 14151
- Determination and use of Radar Scattering Characteristics  
[AGARD LS 59] p0143 N74 11954
- Modeling methods of determining radar echo characteristics by optical ultrasonic and radio methods p0144 N74 11959
- Radar Echoing areas of flying animals p0144 N74 11961
- The use of target and clutter data for different methods of discrimination between targets and unwanted clutter: processing of incoherent video and coherent radar signals p 145 N74 11963
- RADAR EQUIPMENT**  
Sweep frequency backscatter radars as detectors of high latitude ionospheric phenomena p0129 N72 21147
- Biological effects of UHF electromagnetic radar emissions on human organisms p0076 N72 26053
- Analysis of radome design techniques and development of specifications for radome construction  
[AGARD AR 63] p0140 N73 21108
- RADAR IMAGERY**  
Radar imaging application for studying earth resources p0121 N72 16092
- Radar imagery for land use and resource frequency uses of terrain slopes in geographic mapping p0122 N72 16093

- Interpretation of side looking airborne radar imagery for vegetation mapping  
[NASA CR 125451] p0122 N72 16092
- Backscatter properties of ground vegetation for radar waves at X band and Ka band frequencies p0122 N72 16093
- Narrow pulse width radar system for measuring ocean wave heights p0122 N72 16094
- Remote sensing of ocean surface effects and formulation of sea clutter models p0122 N72 16096
- BOAC experience with turbulence performance requirements for clear air turbulence detecting sensor p0058 N74 17726
- RADAR MAPS**  
Presentation and storage of radar cross section data p0145 N74 11964
- RADAR MEASUREMENT**  
Static full scale measurements of RCS p0144 N74 11957
- Dynamic full scale measurement of RCS p0144 N74 11958
- Target characteristics radar measurements on scaled models p0144 N74 11960
- RADAR NAVIGATION**  
Terrain avoidance radar for US Army rotary wing aircraft p0032 N72 11927
- Computerized multistage decision process for radar operator and in collision avoidance trajectory control p0279 N73 23886
- RADAR PHOTOGRAPHY**  
Airborne remote multispectral photographic infrared and side looking radar sensing for locating construction materials p0121 N72 16087
- Microwave radar detection and photography of gravitational waves in troposphere p0137 N73 14152
- RADAR RANGE**  
Boundary layer theory and meteorological parameters for radar range prediction over sea surface p0121 N73 23474
- RADAR SCATTERING**  
Analysis of radar backscatter from the sea: dielectric properties of materials and slant range radar measurements p0126 N72 16119
- High frequency radar backscattering technique for determining ionospheric structure and gravity wave disturbances p0137 N73 14155
- Determination and use of Radar Scattering Characteristics  
[AGARD LS 59] p0143 N74 11954
- Introductory lecture Target scattering characteristics of importance to radars p0144 N74 11955
- Target characteristics radar measurements on scaled models p0144 N74 11960
- State of the art and future prospects p0145 N74 11967
- RADAR SIGNATURES**  
High frequency radar backscattering technique for determining ionospheric structure and gravity wave disturbances p0137 N73 14155
- RADAR TARGETS**  
Determination and use of Radar Scattering Characteristics  
[AGARD LS 59] p0143 N74 11954
- Introductory lecture Target scattering characteristics of importance to radars p0144 N74 11955
- Use of radio modeling data for radar target assessment p0145 N74 11965
- The use of RCS data for radar systems design p0145 N74 11966
- RADAR TRANSMISSION**  
Tropospheric characteristics and their effects on radio propagation: wave propagation and radio signal transmission  
[AGARD CP 70 71 P1 1] p0114 N71 21409
- Improved tropospheric wave propagation for military applications p0114 N71 21410
- Satellite cloud cover observations for determining radio and radar propagation characteristics p0114 N71 21414
- Tropospheric stratification on effects on radio propagation and signal distortion p0116 N71 21423
- Polar propagation effects on HF radar in auroral and subauroral regions p0129 N72 21142
- RADIAL FLOW**  
Design and component testing of cooled radial gas turbine engine p0258 N71 17381
- RADIANT FLUX DENSITY**  
Radiance distribution as function of depth in upper layers of ocean and numerical analysis of coherent and apparent optical properties p0241 N73 23621
- RADIATION DOSEAGE**  
Passive dosimetry for measuring cosmic radiation dosage and its effects during manned space flight p0075 N72 26048
- Passive dosimetric interpretation of cosmic radiation dose rate aboard Free Flight type of Canadair C911 supersonic transport aircraft p0075 N72 26052
- RADIATION EFFECTS**  
On the effects of ionizing radiation on biological systems: problems of dosimetry and radiobiology and their effects during high altitude flight, manned space flight, and ground based equipment  
[AGARD CP 95 P1 3] p0075 N72 26045
- Biological effects of UHF electromagnetic radar emissions on human organisms p0076 N72 26053

- Navy research and instrumentation for analyzing nonionizing radiation effects on human personnel p0076 N72 26054
- RADIATION HAZARDS**  
Biophysical hazards of cosmic radiation during SST and manned space flight p0075 N72 26046
- RADIATION INJURIES**  
Navy research on laser caused visual acuity decrement in monkeys and ocular injury in humans p0076 N72 26056
- Safety codes for operators using laser equipment p0076 N72 26057
- RADIATION MEASUREMENT**  
Statistical estimating techniques for inversion of radiative transfer equation in determining atmospheric temperature from microwave radiation measurements p0125 N72 16113
- RADIATION MEASURING INSTRUMENTS**  
Navy research and instrumentation for analyzing nonionizing radiation effects on human personnel p0076 N72 26054
- RADIATION PROTECTION**  
Active dosimetry for protection and control of cosmic rays in supersonic aircraft p0075 N72 26047
- RADIO ATTENUATION**  
Measurements of rainfall attenuation at millimeter wavelengths p0114 N71 21415
- Airborne measurements on radio attenuation and radar reflectivity by precipitation by microwave frequencies p0115 N71 21417
- Tropospheric attenuation of low incidence satellite radio signals at 15 to 20 wavelengths p0115 N71 21420
- Radio attenuation in prediction method using stratified atmospheric level indices p0120 N71 23468
- Analysis of 11 GHz band propagation in Portugal for rain accumulation prediction p0148 N74 13889
- RADIO BEACONS**  
Measurements on microwave attenuation by precipitation by ATS 5 satellite beacon p0115 N71 21419
- Tropospheric scattering field strength analysis by synchronously offset radio beacon transmissions p0118 N71 23455
- Design development and application of flight recorders and crash location instruments used in NATO nations  
[AGARD AR 39] p0195 N72 32457
- RADIO COMMUNICATION**  
Analysis of amplitudes and frequencies of signal fading in satellite to aircraft radio links due to multiplexing of radio signals p0194 N72 19509
- Interchannel interference and Gaussian noise effects on phase modulated digital microwave radio systems p0134 N73 10211
- Conference on acoustic gravity wave effects in atmospheric transmission of radio communication signals  
[AGARD CP 115] p0134 N73 14131
- RADIO ECHOES**  
Modeling methods of determining radar echo characteristics by optical ultrasonic and radio methods p0144 N74 11959
- RADIO ELECTRONICS**  
Systems performance and safety in helicopter approach and landing and radioelectronic guidance arrays p0024 N72 11939
- RADIO FREQUENCIES**  
Development and characteristics of three axis radio frequency attitude sensor for geostationary satellite p0191 N72 19492
- RADIO FREQUENCY INTERFERENCE**  
Interchannel interference and Gaussian noise effects on phase modulated digital microwave radio systems p0134 N73 10211
- Conference on acoustic gravity wave effects in atmospheric transmission of radio communication signals  
[AGARD CP 115] p0134 N73 14131
- Atmospheric gravity wave effects on complex transverse natural radio wave propagation in presence of traveling ionospheric disturbances p0139 N73 14164
- Effects of traveling ionospheric disturbances following nuclear explosion on high frequency band propagation p0139 N73 14167
- The interrelation of propagation effects and design factors for fixed service communications satellite systems p0149 N74 13871
- RADIO HORIZONS**  
Very high frequency and ultrahigh frequency transmission signal propagation modes p0116 N71 21426
- RADIO INTERFEROMETERS**  
Characteristics of interferometric antenna arrays for very high frequency radio interferometry p0134 N73 10213
- RADIO METEOROLOGY**  
Climatology and atmospheric radio wave model for worldwide radio wave propagation p0114 N71 21412
- RADIO RELAY SYSTEMS**  
Radio attenuation and multipath fading in ultrahigh frequency radio relay systems p0142 N73 26134
- Radio attenuation statistics for ultrahigh frequency microwave radio relay systems and data p0142 N73 26135
- Multipath fading measurements for planning ultrahigh frequency radio link p0142 N73 26137
- Effects of ionospheric atmospheric disturbances on ultrahigh frequency radio communication reliability p0143 N73 26141

## SUBJECT INDEX

The radiation diagrams of antennas used in terrestrial microwave line of sight systems. radiation patterns of parabolic antennas in terrestrial relay system. p0147 N74 13859

### RADIO SCATTERING

Ray tracing computations of high frequency signal propagation and dispersion in traveling atmospheric disturbances. p0139 N73 14165

Multiple scattering and attenuation of radio signals caused by rainfall. p0140 N73 26122

Precipitation models from radar and rainfall data for predicting radio scattering in rainstorms. p0148 N74 13854

Measurements of precipitation scatter at 11.8 GHz. p0147 N74 13855

### RADIO SIGNALS

Tropospheric attenuation of low incidence satellite radio signals at 15 to 20 wavelengths. p0115 N71 21420

Ducting in microwave propagation on transhorizon path over sea. p0118 N71 21427

High latitude studies of scintillation in radio signals from radio sources and satellites. p0128 N72 21137

### RADIO SOURCES (ASTRONOMY)

High latitude studies of scintillation in radio signals from radio sources and satellites. p0128 N72 21137

### RADIO SPECTRA

Use of radio modeling data for radar target assessment. p0145 N74 11965

### RADIO TELEMETRY

Tropospheric turbulence effects on super-high frequency transmissions at low elevation angles. p0115 N71 21422

### RADIO TELESCOPES

Homologous deformation of stiffened shells for radio telescope structures. p0298 N74 15616

### RADIO TRANSMISSION

Climatology and atmospheric refraction models for worldwide radio wave propagation. p0114 N71 21412

Satellite cloud cover observations for determining radio and radar propagation characteristics. p0114 N71 21414

Real time weather radar data on tropospheric microwave attenuation by rain. p0114 N71 21416

ATS 5 down link 15 GHz signal propagation compared to ground based radio and meteorological data. p0115 N71 21418

Tropospheric stratification effects on radio propagation and signal distortion. p0118 N71 21423

Radio refractivity calculations for tropospheric elevated layers during transhorizon propagation. p0116 N71 21424

Very high frequency and ultrahigh frequency transhorizon signal propagation models. p0116 N71 21426

Very high frequency signal fading in diffraction scatter path propagation. p0117 N71 21431

Tropospheric scatter propagation and prediction of radio transmission characteristics. p0117 N71 21431

[AGARD CP 70 71]. p0117 N71 21431

Tropospheric refractivity variation effects on radio wave scatter propagation. p0117 N71 21432

Antenna response patterns of Doppler spectra and amplitude distributions of transhorizon microwave scatter propagation. p0117 N71 21433

Scanning forward scatter mapping and turbulent layer model for tropospheric scatter propagation analysis. p0118 N71 21434

Tropospheric scattering field strength analysis by synchronously offset radio beam transmissions. p0118 N71 21435

Atmospheric circulation model for analyzing tropospheric ultrahigh frequency signal fading. p0118 N71 21436

Mathematical model for partial reflection from tropospheric layers in radio transhorizon propagation. p0118 N71 21437

A regular diversity propagation pattern of spaced antennas in tropospheric transhorizon scatter link. p0118 N71 21439

Maxwell field theory for solving wave path reliability in tropospheric scatter propagation. p0119 N71 21462

Multipath transmission models for predicting signal distortion and intermodulation in tropospheric scatter propagation. p0119 N71 21463

Mathematical model for frequency correlation function of tropospheric scatter channel. p0119 N71 21464

Impulse response measurements and laboratory test for evaluating tropospheric scatter propagation channel capacity. p0119 N71 21466

Computerized simulation of tropospheric scatter channel distortion using Monte Carlo method. p0119 N71 21467

Path loss prediction methods for tropospheric scatter scatter propagation links and comparison with performance tests. p0120 N71 21469

Mathematical prediction model for tropospheric radio transmission loss over rough surfaces. p0120 N71 21472

Ray tracing computations of high frequency signal propagation and dispersion in traveling atmospheric disturbances. p0119 N71 21465

Nonspherical random dielectric model of atmospheric wave in ultrahigh frequency radio link. p0140 N73 26121

Multipath propagation and phase delay in ultrahigh frequency radio wave caused by atmospheric disturbance. p0140 N73 26124

Attenuation and phase dispersion of radio wave in atmosphere due to oxygen microwave spectrum. p0141 N73 26126

Ultrahigh frequency coherent radio signal transmission for differential phase shift measurement due to vapor and oxygen absorption lines. p0141 N73 26131

Point rainfall rate statistics for predicting ultrahigh frequency radio propagation. p0142 N73 26136

Calculation of electromagnetic wave absorption by rain for frequencies close to 30 GHz. p0142 N73 26138

Thunderstorm cloud height and fading statistics for ATS 5 ultrahigh frequency signal transmission to earth. p0142 N73 26141

Propagation effects of frequency sharing. p0145 N74 11946

[AGARD CP 127]. p0145 N74 11946

The propagation of electromagnetic waves over irregular terrain. radio wave diffraction and transmission loss. p0146 N74 13848

Radio wave diffraction due to a mountain of volcanic origin. p0146 N74 13851

Troposcatter propagation in an equatorial climate. p0148 N74 13865

Measurement of atmospheric attenuation at the frequencies of 15, 19, and 34 GHz. atmospheric effects on microwave transmission. p0149 N74 13870

### RADIO WAVE REFRACTION

Slant path attenuation of ultrahigh frequency signals from sun tracking radars. p0142 N73 26140

Tropospheric influence on the screening effect due to a mountain ridge on 3 GHz radio transmission loss due to atmospheric refractivity. p0146 N74 13853

Ducting properties of elevated layers. p0147 N74 13862

### RADIO WAVES

Tropospheric characteristics and their effects on electromagnetic wave propagation and radio signal transmission. [AGARD CP 70 71 PT 1]. p0114 N71 21419

Tropospheric scattering and delay effects on electromagnetic wave propagation in space communications. p0114 N71 21413

Statistical evaluation of fading caused by intermodulation in combined long wave broadband propagation. p0117 N71 21433

Characteristics and effects of A-type ionosphere on radio and radar propagation. conference. p0126 N72 21121

Auroral radar network for statistical and single event studies of radio emission morphology and scattering mechanisms. p0127 N72 21127

Radio wave scattering from auroral ionization. [NASA TM X 68102]. p0127 N72 21131

Low acoustic waves in auroral plasma and radio wave scattering. p0127 N72 21132

Radio wave propagation in the A-type ionosphere. p0127 N72 21133

Angular deviations of radio waves from horizontal stratification. p0128 N72 21139

Effects of A-type ionosphere characteristics on radio and radar propagation. p0130 N72 22136

Atmospheric gravity wave effects on tropospheric transhorizon radio wave propagation in presence of traveling ionospheric disturbances. p0139 N73 14164

Variations in diffraction loss due to tropospheric effects at frequencies between 180 MHz and 10 GHz in hilly terrain. p0146 N74 13852

### RADIOACTIVE MATERIALS

Development and characteristics of instrument fading system using radioactive material as a light source for guide slope and alignment information. p0234 N73 23707

### RADIOGRAPHY

Neurology and radiographic observation of spinal fracture and articular facet derangement patterns in thoracic vertebrae. [JAMR TR 71 12]. p0101 N72 19139

### RADIOLOGY

Radiological observations of spinal fractures in the thorax caused by sudden explosion. p0102 N72 19140

Radiological spinal examination of combat pilots and landing angle for ejection. p0142 N72 25057

### RADIOMETERS

Error correction procedure for radiometric infrared sea surface temperature measurements. p0174 N72 16105

Effects of cloud thickness on infrared radiometric atmospheric temperature measurements. p0124 N72 16106

Characteristics of imaging radiometers as stated in meteorological satellites for observing infrared and visible regions. p0192 N72 15497

Measurements of atmospheric attenuation at the frequencies of 15, 19, and 34 GHz. atmospheric effects on microwave transmission. p0149 N74 13870

Some comments on methods of predicting the effects of multiple scattering of radio waves and the practicality of detecting radar targets. p0142 N73 26141

### RADOME MATERIALS

A review of radome design techniques and development of type materials for radome construction. [AGARD AR 53]. p0141 N73 23108

### RADOMES

Analysis of radome design techniques and development of type materials for radome construction. [AGARD AR 53]. p0141 N73 23108

### RAIN

Measurements of rainfall attenuation of radio waves at microwave wavelengths. p0113 N71 21415

Real time weather radar data on tropospheric microwave attenuation by rain. p0114 N71 21416

Point rainfall rate statistics for predicting ultrahigh frequency radio propagation. p0142 N73 26136

## REENTRY VEHICLES

Effects of rain and atmospheric turbulence on ultrahigh frequency space communication radio link. p0143 N73 26143

### RAINDROPS

Conference on atmospheric attenuation and rainfall effects on ultrahigh frequency telecommunication systems [AGARD CP 107]. p0140 N73 26121

Multiple scattering and attenuation of radio signals caused by rainfall. p0140 N73 26122

Nonspherical random dielectric model of atmospheric wave in ultrahigh frequency radio link. p0140 N73 26123

Rain depolarization of linearly and circularly polarized microwaves. p0141 N73 26127

Horizontal radio link system for measuring ultrahigh frequency absorption spectrum due to rain. p0141 N73 26130

Scattering in transhorizon ultrahigh frequency radio link due to rain. p0141 N73 26133

Rain attenuation and multipath fading in ultrahigh frequency radio relay systems. p0142 N73 26134

Rain attenuation statistics for ultrahigh frequency microwave link using meteorological data. p0142 N73 26135

Calculation of electromagnetic wave absorption by rain for frequencies close to 30 GHz. p0142 N73 26138

### RAINSTORMS

Precipitation models from radar and rainfall data for predicting radio scattering in rainstorms. p0146 N74 13854

### RAMJET ENGINE

Design and characteristics of turbojet power source to operate within hypersonic and supersonic systems. [AGARD AR 54]. p0085 N73 19048

### RANDOM LOADS

Summary of papers presented to AGARD conference on random load paper. [AGARD AR 54]. p0292 N73 28884

### RANDOM PROCESSES

Modeling of random human visual search performance based on statistical properties of eye. p0302 N73 19961

### RANGE FINDING

Techniques for long range vision underwater using range gating and dual scan with passive techniques. p0242 N73 33636

### RARE EARTH ELEMENTS

Effects of oxide dispersions and rare earth elements on properties of Cr and Mn alloys. p0262 N73 23608

### RAREFIED GAS DYNAMICS

Drag hypersonic rarefied flow effects on supersonic drag and fueling drag. p0021 N74 14730

### RATES (PER TIME)

Analysis of 11 GHz band propagation in Portugal for rain accumulation prediction. p0148 N74 13869

### RAY TRACING

Ray tracing method for calculating paths of a duct and gravity waves in atmosphere. p0134 N73 14133

Computerized simulation of gravity wave perturbed traveling ionospheric disturbances using radio ray paths. p0139 N73 14163

Expansions of very low field strength level of ionospheric ray paths over sea. close to meteorological conditions. p0148 N74 13869

### REACTION KINETICS

Chemical Kinetics in the stratosphere. atmospheric ionospheric and atmospheric chemistry based on photochemical reactions. p0218 N74 14279

### REACTION TIME

Stresses and adaptation problems associated with large scale long range rapid reaction time and response times. p0069 N71 20360

Postoperative cardiac catheterization. transposition of the large artery. p0080 N73 21110

Computerized electrocardiography in evaluation of the influence of psychopharmacological drugs on electrocardiogram. p0109 N74 20749

### READERS

A comparison of the readability of the text. p0160 N74 16936

A comparison of the readability of the text. p0161 N74 16938

### REAL TIME OPERATION

Generation and characteristics of computer programs for real time control of aerospace vehicles. p0155 N72 21215

Optimization of real time computer data rate paths with regard to system time. p0132 N73 19196

Real time analysis of multi channel wave propagation in the ionosphere using digital computers. p0081 N73 21064

### RECEPTORS (PHYSIOLOGY)

A laboratory study of receptor function after long term exposure to low frequency noise. p0108 N73 21095

### RECTANGULAR

Method for evaluating the aerodynamic characteristics of rectangular airfoils. p0108 N73 21095

Influence of various aerodynamic factors on the aerodynamic performance of rectangular airfoils. p0108 N73 21095

### REDUNDANCY

Algorithm for redundancy detection in digital data. p0113 N71 21415

### REENTRY VEHICLES

Structural analysis of reentry vehicle water at the nose of a hypersonic vehicle. p0142 N73 26136

Techniques for measuring heat transfer in short duration and rapidly varying flows  
[AGARD AG 185] p0300 N73 20945  
Effects of environmental stresses on materials used in constructing glide reentry vehicles p0201 N73 23601

**REFLEXES**  
A model for the prediction of the nystagmic response to angular and linear acceleration stimuli: mechanism of saccadic generation in vestibulo-ocular reflex p0110 N74 20752

**REFRACTION**  
Geometrical optics solution for plane electromagnetic wave propagation and reflection in nonhomogeneous isotropic medium p0123 N72 16100  
Ionospheric refraction effect on geometry of field aligned ionization at HF and UHF in Northern Hemisphere p0130 N72 21152

**REFRACTIVITY**  
Monte Carlo calculation on error probability distribution in sensing systems caused by refractive index of sensed medium p0125 N72 16115

**REFRACTORY MATERIALS**  
Advanced cooling systems and heat resistant materials for turbine blades of high temperature aeronautical gas turbine engines p0257 N71 17372  
Thermal stress and low cycle fatigue reliability analyses on high temperature structural machine materials p0261 N71 17403  
Structural data on brittle nonmetallic materials for use in designing reentry vehicles [AGARD AG 152 71] p0205 N71 20027  
Borides, carbides, and nitrides of silicon: oxidation resistant refractory compounds for use in gas turbines and reentry vehicles p0203 N73 23616

**REFRACTORY METAL ALLOYS**  
Thermal control coatings for refractory gas turbine materials p0259 N71 17391  
Refractory metal alloys with protective coatings for use in structural components of turbine engines p0203 N73 23614  
Oxidation resistant refractory metal alloys for use in high temperature environments p0203 N73 23615  
Methods of oxidation and corrosion resistance in refractory metal alloys used in gas turbine engines p0202 N73 23617

**REFUELING**  
Aviation fueling facilities and fueling operations p0211 N72 11678

**REGENERATIVE COOLING**  
Design and component testing of cooled radial gas turbine engine p0258 N71 17381

**REGRESSION ANALYSIS**  
Regression analysis of estimation tests and system operating data p0189 N71 36778

**REGULATIONS**  
Procedures for application and revision of Federal Aviation Regulations in determining handling qualities and performance of aircraft p0218 N72 32020

**REINFORCED PLASTICS**  
Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials conference [AGARD CP 83 71] p0206 N72 12492  
Mechanical properties of silica fiber reinforced epoxy composite materials p0207 N72 12493  
Elastomeric measurements of elastic modulus of resin fiber composite materials p0207 N72 12495  
Linear and non-linear stress characteristics of epoxy silica composite materials p0207 N72 12496  
Axial tension test for stress-strain response of matrix and interface of resin-glass epoxy resin composites p0207 N72 12500  
Electrical conductance measurements for determining stress-strain time life of glass fiber reinforced silica based in reinforced plastic materials exposed to water p0208 N72 12505  
Ultrasonic, radiographic, eddy current, and acoustic emission techniques for nondestructive tests of carbon fiber reinforced polymers and failure mechanisms p0290 N72 24935  
Physical and mechanical properties of high strength high modulus carbon fibers and organic resin composite materials p0210 N73 27475  
Analysis of properties of fiber reinforced materials with plastic and matrix matrix composition and application to gas turbine engines p0210 N73 27476  
Characteristics of carbon fiber composite materials and structures with reduced weight fatigue reduction and corrosion resistance p0210 N73 27477  
Production of fibrous metal composites by coating of powder with strong non-forming water and application to aerospace vehicle structures p0210 N73 27478  
Design of filamentary composite materials for application to construction of airframes and spacecraft structures p0210 N73 27479  
Construction of glider aircraft using glass fiber and carbon fiber reinforced plastic composite materials for weight reduction and increased strength p0211 N73 27485  
Application of reinforced composite materials for corrosion resistant aircraft gas turbine engines p0212 N73 27493  
Development of fiber reinforced composite materials for application to strengthening of bridges, aircraft, and vehicles and spacecraft components p0212 N73 27493

**REINFORCED SHELLS**  
Computerized design of stiffened cylindrical shells and adjoining composite heat shield p0284 N71 20137

**REINFORCEMENT (STRUCTURES)**  
Characteristics of carbon fiber composite materials and application for structures with reduced weight fatigue reduction and corrosion resistance p0210 N73 27477  
Application of composite materials to reinforce metallic structures for low cost improvement in structural stability of airframes p0211 N73 27485  
Analysis of dynamics of stiffened plates using finite element modeling of flat and curved stiffened panels p0293 N73 29911

**REINFORCING FIBERS**  
Thermal fatigue behavior of fiber reinforced nickel alloy gas turbine blades p0259 N71 17390  
Mechanical properties of fiber reinforced materials p0206 N71 27043

Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite materials conference [AGARD CP 83 71] p0206 N72 12492  
Elastic sources in elastic stress measurements on fiber reinforced composite materials p0207 N72 12498  
Temperature and fiber orientation effects on mechanical behavior of silicon dioxide epoxy composite materials p0207 N72 12499  
Tensile strength measurements on steel wire reinforced aluminum alloys p0208 N72 12501  
Explosive bonding technique for strengthening aluminum with beryllium wires p0208 N72 12502  
Photoelastic measurement of monofilament wetting by reinforcing resins of composite materials p0208 N72 12506  
Analysis of structural diffusion mechanism between beryllium fiber and aluminum matrix p0208 N72 12507  
Fundamental principles for selecting reinforcements for composite materials p0209 N72 29591  
Application of glass composites all carbon composites and PRD 49 organic fiber material for airframe and spacecraft construction p0211 N73 27482

**RELATIVE BIOLOGICAL EFFECTIVENESS (RBE)**  
Relative biological effects of heavy cosmic ray ions on living tissue p0075 N72 26049

**RELEASING**  
Optimal bomb release intervals from B-52 aircraft bomb system p0005 N71 19383

**RELIABILITY**  
Reliability estimation including failure effect analysis of avionics systems p0189 N71 36777  
Effectiveness of reliability programs for avionics equipment p0189 N71 36779  
Techniques for determining reliability of electronic equipment after acceleration tests p0190 N71 36786  
Benefits of totally integrated reliability test programs p0190 N71 36787  
Operational considerations and systems reliability of military user p0190 N71 36788

**RELIABILITY ANALYSIS**  
Optimum structural design and reliability analysis p0284 N71 20138  
Improvements in military helicopter flight test techniques to provide data for safety, maintainability, and reliability p0047 N73 21013  
Procedures for evaluating fatigue quality of aircraft structures based on large life crack propagation and residual strength p0294 N73 29925  
Acceleration of high strength structural materials for aerospace vehicles and use of fracture control procedures for improved damage tolerance p0294 N73 29928

**RELIABILITY ENGINEERING**  
Cost effectiveness, failure analysis and design techniques for measuring reliability of avionics systems [AGARD LS 47 71] p0189 N71 36776  
Linear module design techniques for system reliability p0190 N71 36781  
Techniques for determining system and equipment reliability requirements p0190 N71 36783  
Measurement of air flow and flow simulation for aircraft testing in wind tunnels p0014 N72 11872  
Performance tests of protective clothing to determine effectiveness against air blast during high speed water p0102 N72 19147

Development of system for ground quality control of semiconductor devices used in design of spacecraft electronic equipment p0191 N72 19487  
Analysis of structural and components subsystems for hermetic and inspection of EUROPA 1 launch vehicle p0191 N72 19490  
Methods for conducting acceptance tests and reliability tests of gyroscopes as part of inertial platform quality control procedures p0278 N73 20689  
Reliability and performance safety of electronic aircraft navigation systems p0047 N73 21012  
Development of fatigue life prediction procedures based on accelerated stress, pore hypothesis, and logarithmic model for design of aircraft structures p0294 N73 29924

**RELIEF MAPS**  
Ratierage of topographic information for planning relief of terrain slopes in geographic mapping p0122 N72 16091

**REMOTE CONSOLES**  
Microfilm test access system which automatically retrieves scans and transmits to remote display terminals utilizing wideband transmission network p0157 N72 22169  
Feasibility analysis of packet switching networks for remote access computing systems p0158 N72 22171

**REMOTE SENSORS**  
Conference on propagation ranges of microwave infrared and photographic remote sensing systems for pollution detection and sea state roughness measurements [AGARD CP 90 71] p0121 N72 16085  
Research and development program for military geophysical information system using airborne radar and multispectral photographic data p0121 N72 16086  
Airborne remote multispectral photographic infrared and side looking radar sensing for locating construction materials p0121 N72 16087  
Analysis of remote Arctic ice pack sensing data obtained by submarine sonar, airborne laser and infrared scanning imagery p0121 N72 16088  
Design and performance of microwave radiometer for airborne sensing of sea ice thickness p0121 N72 16089  
Radar imaging applications for studying earth resources p0121 N72 16090  
Radar imagery for producing cumulative frequency curves of terrain slopes in geographic mapping p0122 N72 16091  
Interpretation of side looking airborne radar imagery for vegetation mapping p0122 N72 16092  
Backscatter properties of ground vegetation for radar waves at X band and Ka band frequencies p0122 N72 16093  
Narrow pulse width radar system for measuring ocean wave heights p0122 N72 16094  
Remote satellite microwave sensing of sea surface roughness using water brightness temperature to determine wind fields p0122 N72 16095  
Remote sensing of ocean surface effects and formulation of sea clutter models p0122 N72 16096  
Side scatter propagation at higher frequencies for monitoring air pollution using remote optical radar and radar techniques p0122 N72 16097  
Effects of atmospheric layers on remote sensing by electromagnetic wave reflections p0123 N72 16098  
Airborne remote radar sensor for depth sounding in Antarctic ice p0123 N72 16099  
Ultrahigh resolution radar for sensing refractive index structure of troposphere p0123 N72 16101  
Underwater acoustic beam width effects on signal scattering at rough surface of sea floor p0123 N72 16102  
History and future developments in infrared and multispectral remote sensing devices p0123 N72 16103  
[NASA TM X 67496] Scattering and attenuation of remote infrared imaging instrument signals during atmospheric propagation p0123 N72 16104  
Error correction procedures for radiometric infrared sea surface temperature measurements p0124 N72 16105  
Effects of cloud thickness on infrared radiometric atmospheric temperature measurements p0124 N72 16106  
Error sources in sea surface temperature measurements by satellite borne scanning infrared sensor p0124 N72 16107  
Multispectral radiometric measurements of land and water regions for planning remote multiband photographic photography p0124 N72 16109  
Aerial multispectral color photography for remote reconnaissance of soils and rocks p0124 N72 16110  
Analysis of satellite multispectral imagery data for tropical land use interpretation p0124 N72 16111  
Thermodynamic optical theory for microwave brightness temperature in rough sea surface emissivity for remote sensing data interpretation p0124 N72 16112  
Monte Carlo calculation on error probability distribution in sensing systems caused by relative index of sensed medium p0125 N72 16115  
Wave mechanics theory for assessing remote sensing of atmospheric turbulence with reliability variations p0125 N72 16116  
Development and characteristics of three altitude bin frequency altitude sensor for geostationary satellite p0191 N72 19492  
Characteristics of sensors for space-borne altitude determination systems for earth-orbiting and earth-orbiting satellites p0192 N72 19495  
Characteristics of sensor systems for geostationary space-borne satellite to determine satellite altitude from transfer and to a ground p0192 N72 19496  
Development of the geostationary satellite to determine altitude from transfer and to a ground p0192 N72 19499  
Application of earth-orbiting satellite systems for remote sensing of the environment [AGARD CP 90 71] p0192 N72 19500  
Some remarks on the methods of avoiding the effects of turbulence on ground measurements of the geostationary satellite to determine altitude p0206 N73 27474

**REPORTS**  
List of reports in the AGARD monograph series. To be published by the publisher, not by the author of AGARD monographs. To be prepared by an author p0306 N74 21601

## REPRODUCTIVE SYSTEMS

- Natural ionizing radiation effects on multiplication of unicellular organisms and Drosophila melanogaster development  
p0075 N72 26050
- Advantages of breeding Rhesus monkeys in compounds for biomedical research  
p0083 N73 23063

## REQUIREMENTS

- Application of control system requirements to development of tactical missile weapon systems  
p0226 N72 27683

## RESCUE OPERATIONS

- Automatic approach and hover computer for rescue helicopter  
p0032 N72 11926

## RESEARCH AND DEVELOPMENT

- Research and development of NATO countries high temperature corrosion of aerospace alloys  
[AGARD R 591]  
p0701 N72 20491
- Role of free flight models in aircraft research and development  
p0045 N73 17002
- Annual AGARD meeting in Brussels, Belgium  
p0304 N73 21881
- The role of OST in information research and development  
p0160 N74 16929
- AGARD Annual Meeting, 1973 conference on research and development in Greece and use in science and technology to meet military requirements at reduced costs  
p0304 N74 21610
- Research and development activities in Greece  
p0305 N74 21611
- Research work and costs: the role of data processing in aircraft production  
p0305 N74 21612
- Director's annual report, 1970 to the NATO Military Committee  
p0305 N74 23482
- Highlights AGARD's twentieth anniversary, 1952-1972  
p0306 N74 23488
- Director's annual report to the North Atlantic Military Committee, 1972  
p0306 N74 23499
- Highlights spring 1973 of progress of AGARD papers  
p0306 N74 23500

## RESEARCH FACILITIES

- Research organizations, investigations and programs in high temperature research facilities NATO countries and Spain  
[AGARD R 585 71]  
p0302 N71 16582
- Research program methods and facilities Philips test center, France  
p0303 N72 07000
- Organization and operation of US Air Force Test Pilot School  
p0306 N72 20994
- Research activities of electronic laboratory in development of tactical navigation systems, possible applications for space missions and commercial aviation  
p0307 N73 20886
- Problems of theory and information sciences in large research center  
p0158 N73 24704
- Directory of research activities in institutions possible  
[AGARD R 609]  
p0304 N74 17664
- RESEARCH MANAGEMENT
- The 1972 AGARD Annual Meeting  
p0306 N74 23494
- Director's annual report to the North Atlantic Military Committee, 1971  
p0306 N74 23496
- AGARD handbook including AGARD laws  
p0306 N74 23497

## RESEARCH PROJECTS

- Research organizations, investigations and programs in high temperature research from eleven NATO countries and Spain  
[AGARD R 585 71]  
p0302 N71 16582
- Review of research projects in aircraft handling qualities, vehicle stability and control characteristics  
p0304 N72 32038
- An Air Force research and development program in aircraft electrical power systems to show promising progress for developing specific classes of technology  
[AGARD R 591]  
p0306 N73 19057
- Research program of electronic laboratory in development of tactical navigation systems for tactical applications for space missions and commercial aviation  
p0307 N73 20886
- German research program in international aerodynamic research  
p0304 N73 21059
- Proceedings of conference on military application of V-100 aircraft in Europe, North and South America, presented research projects in the program  
[AGARD R 591]  
p0304 N73 21060
- United States Department of Transportation research program on high speed aircraft  
p0307 N74 14273
- Technical evaluation of aerodynamic characteristics of aircraft  
p0307 N74 14273

## RESEARCH VEHICLES

- Research aspects of aerodynamic and performance of vehicle capable of moving in penetrating and performing maneuver flights in an environment of water  
p0307 N72 11927

## RESIN BONDING

- Effect of resin bonding on mechanical properties of aircraft wing structure in penetrating and performing maneuver flights in an environment of water  
p0307 N72 11927

## RESONANT FREQUENCIES

- Effect of resonant frequencies on generalized stresses by FEM for all four-dimensional finite element method  
[AGARD R 591]  
p0306 N72 23495

## RESPIRATION

- Respiratory gas analyzer for aircrew pulmonary function measurements  
[NASA TM X 68370]  
p0074 N72 25057

## RESPIRATORS

- Effects of positive G<sub>y</sub> acceleration on blood oxygen saturation and pleural pressure relations in dogs breathing air and liquid fluorocarbons in whole body water immersion respirator  
[NASA CR 117199]  
p0068 N71 20358

## RESPIRATORY RATE

- Formula for predicting physical fitness of flying personnel in Belgian Air Force during aging process from spirometric measurements  
p0094 N71 22321

## RETINA

- Effects of accelerated particles and cosmic rays on light images in human eye  
[NASA TM X 68460]  
p0075 N72 26051
- Modeling of random human visual search performance based on physical properties of eye  
p0302 N71 19961

## RETIREMENT

- Coronary system diseases in aging flight crews at retirement from flying status  
p0093 N71 22315

## REYNOLDS NUMBER

- Conference on theoretical methods and wind tunnel facilities for transonic aerodynamic testing of aircraft at high Reynolds numbers  
[AGARD CP 83 71]  
p0011 N72 11854
- Scale effects in flows past swept wings at transonic speeds  
p0011 N72 11855
- Reynolds number effects in viscous-inviscid interactions on transonic swept wings  
p0011 N72 11856
- Method for estimating transonic buffet boundary and Reynolds number effects for straight and swept wings  
p0011 N72 11857
- Minimum level of Reynolds number for reliable flow simulation in transonic test facilities  
[NASA TM X 67412]  
p0012 N72 11859
- Transonic wind tunnel determination of Reynolds number effect on jet flapped airfoil drag divergence, pressure distribution and buffet onset  
p0012 N72 11861
- Wind tunnel measurements of Reynolds number effect on force and pressure coefficients for slender delta wing at transonic speed  
p0012 N72 11863
- Reynolds number effect on flow past body of revolution at transonic speed  
p0012 N72 11864
- Transonic wind tunnel testing requirements for simulating transonic aerodynamic data at high Reynolds numbers  
p0014 N72 11873
- Equivalent body of revolution for simulating high Reynolds number effect on transonic flow past two dimensional airfoil  
p0014 N72 11874
- Wind tunnel model boundary layer reduction through suction for accurate simulation of high Reynolds number full scale aircraft drag results  
p0014 N72 11875
- Aerodynamic suitability of F-12 for wind tunnel testing of transport aircraft models at increasing Reynolds numbers and subcritical and supersonic Mach numbers  
[NASA TM X 67412]  
p0015 N72 11879
- Comparison between conventional blowdown and Ludwieg tube driven transonic wind tunnels for high Reynolds number range  
p0015 N72 11881
- Performance characteristics of high Reynolds number tube wind tunnel  
p0015 N72 11882
- Speed of sound in high Reynolds number wind tunnel development for flow simulation in swept wing aircraft development tests  
p0015 N72 11883
- Performance and operational characteristics of high Reynolds number flow tunnel at shock wave tunnels for aerospace model testing  
p0016 N72 11884
- Transonic wind tunnel development for model testing at high Reynolds number  
p0016 N72 11887
- A review of effects of Reynolds number on aerodynamic stability of aircraft wings at a relationship of Reynolds number to aerodynamic coefficients of blade elements  
p0018 N73 22957
- Influence of free stream Reynolds number on transition in boundary layer flow over swept wing  
p0018 N73 26289
- Present and future need for high Reynolds number transonic wind tunnels in design analysis and design selection and requirements  
p0018 N73 26282

## RHYTHM (BIOLOGY)

- Using time series and regression analysis of rhythmic heart data from rat of German Air Force  
p0097 N72 14103

## RHYTHM (BIOLOGY)

- Spectral analysis of human ECG rhythm performance to evaluate transport effects  
p0018 N73 21116

- Effects of biofeedback training on chemotherapy and drug metabolism  
p0018 N73 21119

## RIGID ROTORS

- Effect of elastic flapping of rotor blades on stability and control of helicopter equipped with hingeless rotor system  
p0047 N73 21016
- Flight tests of Westland Scout helicopter fitted with reduced scale version of rigid rotor to determine growth in stall and handling characteristics  
p0047 N73 21017
- Analysis of factors influencing performance of rotary wing aircraft and mathematical models of stability and flow characteristics  
p0047 N73 21019
- Survey of problems encountered in prediction of structural design loads and aerodynamic stability margins during development of rotary wing aircraft  
p0048 N73 21020
- Structural concepts of rotary wing system capsules to show changes in design of specific vertical takeoff aircraft components  
p0048 N73 21021
- Aerodynamic characteristics of rotorcraft controlled rotor and fundamental problems of stopped rotorcraft  
p0048 N73 21024
- Development of jet flap, flap and applications to heavy helicopter and stoppable rotor development  
p0048 N73 21025
- Development of rotary wings with fold, fold and fixed cycle jet propulsion systems and applications for large free rotor drive systems  
p0049 N73 21026
- Review of rotary rotor technology and its expansion of the rotor performance with standard rotor wing  
p0049 N73 21027
- Development of advanced blade concept rotary wing and rotor blade design  
p0049 N73 21029
- Proceedings of conference on fluid dynamics of rotary wings and aerodynamic characteristics of rotary wing systems  
p0049 N73 21033
- Analysis of a rotorcraft for rotary wing performance characteristics of hovering rotary wing as a function of rotor performance  
p0049 N73 21032
- Development of a rotorcraft theory for predicting time averaged downwash distribution and response characteristics of the rotorcraft in forward flight  
p0049 N73 21033
- Proprietary design suggesting velocity distribution through helicopter rotor blade tip vortex using a single tip vortex rotor blade  
p0049 N73 21034

## RIGID WINGS

- Calculation of induced load effects on controllability of rigid and flexible aircraft  
p0045 N73 17004

## RIOMETERS

- Spatial correlation of aureole radio absorption using riometers  
p0129 N72 21146

## RIVETED JOINTS

- Nondestructive tests and their application for inspection of adhesive bonded structures, welded joints, and riveted or bolted joints  
p0197 N72 19542

## ROCKET ENGINE CASES

- Failure analysis of fiber reinforced composite rocket engine case using distortion energy and maximum strain theories of failure  
p0213 N73 27500

## ROCKET ENGINES

- Application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers  
[AGARD AG 168]  
p0300 N73 31830
- Gas sampling and analysis in combustion phenomena  
[AGARD GRAPH 168IFR]  
p0111 N72 27999

## ROCKET LAUNCHERS

- External store interference caused by rocket launcher port positioning on aircraft wing  
p0006 N71 19387

## ROCKET PROPELLED BLED

- High Reynolds number aerodynamic ground testing by moving test specimens on rocket sleds  
p0016 N72 11885

- Inertial guidance system sled testing  
p0237 N74 14354

## ROLLING

- Production of fibrous metal composites by rolling of powder with strong reinforcing wires and application to aerospace vehicle structures  
p0210 N73 27478

## ROLLING MOMENTS

- Angle of attack effects on induced rolling moment of low aspect ratio missile at transonic speed  
p0007 N71 19363

## ROTARY WINGS

- Effects of semi-rigid rotors on helicopter autostabilizer design  
p0032 N72 11928
- Design of stability augmentation system for Westland Scout helicopter  
p0033 N72 11930
- Proceedings of conference to analyze static and dynamic loads exerted on helicopter rotary wings and application to improved helicopter design  
[AGARD R 591]  
p0016 N73 14000
- Developments in unsteady aerodynamics of helicopter rotary wings to analyze stall flutter transient effects of interactions and wake induced instabilities  
p0017 N73 14001
- Application of model helicopter rotor experiments to determining dynamic stall of rotary wings and predicting aerodynamic loads developed  
p0017 N73 14002
- Numerical analysis of unsteady aerodynamic forces on helicopter rotor blades to determine lift distribution as function of velocity component normal to blades  
p0017 N73 14003
- Proceedings of conference on rotary wing aircraft developments to include operational experience flight tests and evaluation of structural concepts  
[AGARD CP 21]  
p0048 N73 21008
- Effect of elastic flapping of rotor blades on stability and control of helicopter equipped with hingeless rotor system  
p0047 N73 21016
- Flight tests of Westland Scout helicopter fitted with reduced scale version of rigid rotor to determine growth in stall and handling characteristics  
p0047 N73 21017
- Analysis of factors influencing performance of rotary wing aircraft and mathematical models of stability and flow characteristics  
p0047 N73 21019
- Survey of problems encountered in prediction of structural design loads and aerodynamic stability margins during development of rotary wing aircraft  
p0048 N73 21020
- Structural concepts of rotary wing system capsules to show changes in design of specific vertical takeoff aircraft components  
p0048 N73 21021
- Aerodynamic characteristics of rotorcraft controlled rotor and fundamental problems of stopped rotorcraft  
p0048 N73 21024
- Development of jet flap, flap and applications to heavy helicopter and stoppable rotor development  
p0048 N73 21025
- Development of rotary wings with fold, fold and fixed cycle jet propulsion systems and applications for large free rotor drive systems  
p0049 N73 21026
- Review of rotary rotor technology and its expansion of the rotor performance with standard rotor wing  
p0049 N73 21027
- Development of advanced blade concept rotary wing and rotor blade design  
p0049 N73 21029
- Proceedings of conference on fluid dynamics of rotary wings and aerodynamic characteristics of rotary wing systems  
p0049 N73 21033
- Analysis of a rotorcraft for rotary wing performance characteristics of hovering rotary wing as a function of rotor performance  
p0049 N73 21032
- Development of a rotorcraft theory for predicting time averaged downwash distribution and response characteristics of the rotorcraft in forward flight  
p0049 N73 21033
- Proprietary design suggesting velocity distribution through helicopter rotor blade tip vortex using a single tip vortex rotor blade  
p0049 N73 21034

Development of procedure for determining geometry and strength distribution of vortex wake generated by single-bladed hovering helicopter rotor p0049 N73 21035

Parameters for enhancing performance of helicopter rotors during stationary flight p0049 N73 21036

Wind tunnel tests of rotary wing to determine retreating blade stall at several preset parameters and effect of reverse flow area p0049 N73 21037

Improvements in basic rotary wing design and tests to determine effects on helicopter performance p0050 N73 21038

Aerodynamic characteristics of rotary wings under axial flow conditions and development of numerical analysis techniques p0050 N73 21039

Development of method for predicting performance of heavily loaded propellers and rotors in steady hovering flight p0050 N73 21040

Analysis of unsteady aerodynamic environment of rotary wings and research projects to improve understanding of rotor unsteady airflows p0050 N73 21041

Analysis of unsteady aerodynamic loading on reference section of helicopter rotor blade in axial or hovering flight under compressible flow conditions p0050 N73 21044

Effect of rotary wing airfoil modifications on performance stability and control of helicopters p0051 N73 21045

Developments in techniques for analyzing boundary layer characteristics of rotary wings based on unsteady viscous inviscid interaction p0051 N73 21046

Development of technique for rotor blade design and measurement of pressure distributions along the blade chord and across blade wake near rotor tip in flight p0051 N73 21047

Development of algorithm for calculating inviscid flow about arbitrary planform rotors and application to analyzing various rotating configurations p0051 N73 21048

Development of concept of circulation control applied to rotary wings to show effects on hover, transition, and high speed cruise performance p0051 N73 21050

Aerodynamic dynamic and aerostatic problems in rotary wing design for helicopters and V-STOL aircraft with application to hingeless rotor systems p0051 N73 21051

Analysis of aerodynamic noise produced by rotary wings and methods for noise reduction based on shed vortex wakes and blade tip modification p0052 N73 21053

Generation of aerodynamic noise by turbulent wake behind rotary wing airfoil and relationship to drag and lift coefficients p0052 N73 21054

Noise spectrum characteristics and directivity patterns for rotary wings as function of blade tip speed, total rotor thrust, and angle of rotor disc plane p0052 N73 21055

Analysis of helicopter blade flutter for both hinged and hingeless rotor blades p0052 N73 21056

[AGARD R 607] p0052 N73 21920

Proceedings of conference on rotary wings to investigate rotor wakes, aerodynamic characteristics at hover and high advance ratio, and aerodynamic noise properties [AGARD AR 61] p0052 N73 21931

Analysis of aerodynamic and dynamic properties of rotary wing aircraft for application to design development and evaluation of helicopters [AGARD LS 63] p0017 N73 22948

Aerodynamic characteristics of helicopter with emphasis on airframe aerostaticity and mechanical instabilities p0017 N73 22949

Fundamentals of rotary wing aerodynamics and application to performance considerations of helicopters p0017 N73 22950

Basic dynamics of rotary wings: mechanics of helicopter flight and aerodynamic characteristics of advanced rotary wing concepts and configurations p0017 N73 22951

Effects of aerostaticity on performance of rotary wings and procedures for predicting aerodynamic forces on rotary wing blades p0017 N73 22952

Effects of aerodynamic drag on rotary wing performance and methods for reducing influence of stall and compressibility parameters p0017 N73 22954

Procedures for testing rotary wing aircraft models in wind tunnels to include design of test facilities, cost of models and facilities, and methods for obtaining data p0018 N73 22955

Analysis of effects of Reynolds number on aerodynamic stalling of rotary wings and relationship of Reynolds number to aerodynamic coefficients of blade elements p0018 N73 22957

Analysis of effects of aerodynamic and dynamic parameters on design synthesis of rotary wings and application of optimization techniques p0018 N73 22958

Flight test procedures for rotary wing aircraft with emphasis on performance and flying qualities p0018 N73 22959

Application of glass-reinforced and carbon-reinforced composite materials for helicopter structures and rotary wings p0018 N73 22960

Specialists Meeting on Helicopter Rotor Prediction Methods [AGARD CP 122] p0055 N74 10908

Rotor wing design methodology based on nonlinear aerostatic blade loads analysis p0056 N74 10909

Current trends technology for helicopter rotors based on rotor loads computer program for determining fatigue design loads p0056 N74 10910

Prediction of helicopter rotor loads based on alternate aerodynamic loads imposed on rotor wing and rotor hub p0058 N74 10911

Helicopter rotor loads prediction assumptions and techniques for numerical analysis of aerodynamic loads p0056 N74 10912

Rotor system design and evaluation using a general purpose helicopter flight simulation program p0056 N74 10913

The prediction of loading actions on high speed semi-rigid helicopters p0056 N74 10914

Loads prediction methods for hingeless rotor helicopters p0056 N74 10915

Integrated rotor body loads prediction p0057 N74 10916

Dynamic stall [NASA CR 136473] p0018 N74 13709

ROTATING BODIES  
Magnus characteristics of arbitrary rotating bodies [AGARD AG 171] p0018 N74 13710

ROTATING DISCS  
Fabrication of cobalt alloy and nickel alloy gas turbine blades and disks p0059 N71 17392

Design fabrication and test of boron polyimide reinforced titanium fan disks to operate at high temperatures p0013 N73 27498

Performance and endurance of compressive disks bound with boron composite wires p0013 N73 27499

ROTATING ENVIRONMENTS  
Stabilization of turbulent shear layer flow in rotating systems by control forces p0180 N72 20305

ROTATING GENERATORS  
Development of superconducting homopolar machines with multiple disk and superconducting field winding using liquid metals for armature sliding contacts p0064 N73 19037

ROTATING SHAFTS  
Methods of testing rotating components of turbomachines compared with tests on complete turbomachines p0059 N71 17392

[AGARD AG 167] p0071 N72 26800

AGARD flight test instrumentation series Volume 4: The measurement of engine rotation speed [AGARD AG 160 VOL 4] p0196 N74 14116

ROTATING STALLS  
Interference effect between oscillating and distorted inlet flow on compressor stall p0003 N71 19370

ROTATION  
Intuitive graphical and simplified mathematical treatment of rotational dynamics as applied to human centrifuges p0094 N71 17740

ROTOR AERODYNAMICS  
Proceedings of conference on rotary wings to investigate rotor wakes, aerodynamic characteristics at hover and high advance ratio, and aerodynamic noise properties [AGARD AR 61] p0052 N73 21931

ROTOR BLADES  
Development of advancing blade concept rotary wing and wind tunnel tests of full scale model p0048 N73 21029

Procedures for measuring velocity distribution through helicopter rotor blade tip vortex using single full scale rotor blade p0049 N73 21034

Wind tunnel tests of rotary wing to determine retreating blade stall at several preset parameters and effect of reverse flow area p0049 N73 21037

Development of technique for rotor blade design and measurement of pressure distributions along the blade chord and across blade wake near rotor tip in flight p0051 N73 21047

Analysis of helicopter blade flutter for both hinged and hingeless rotor blades [AGARD R 607] p0052 N73 21920

Application of boron aluminum composite material for construction of turbine blades with low notch sensitivity in high cycle fatigue p0013 N73 27497

ROTOR BLADES (TURBOMACHINERY)  
Temperature field measurements within convection cooled rotor blade of gas turbine engine p0059 N71 17387

Impact cooling method for turbine rotor blades p0060 N71 17397

Heat transfer and thermal stress calculations for gas turbine rotor blade design p0061 N71 17401

ROTOR  
Flight characteristics and performance of Fenestron type helicopter tail rotor p0048 N73 21028

# S

S-3 AIRCRAFT  
Role of flight simulation in development of S-3 and F-14 aircraft p0045 N73 17001

SA-330 HELICOPTER  
Autonomous navigation system for SA-330 helicopter and flight test methods p0037 N72 17929

SACCADEE EYE MOVEMENTS  
Computer electronic techniques in evaluating the influence of psycho-pharmacological drugs on vigilance p0109 N74 20749

SAFETY DEVICES  
Safety device study for human protection during impact acceleration p0100 N72 19131

Structural crashworthiness performance of conventional automobile and performance of structural devices designed for protection p0101 N72 19142

## SAFETY FACTORS

Safety measures to eliminate aircraft trailing vortex hazards [NASA TM X 67125] p0028 N71 23418

Speed and field length safety factors for approach and landing mechanics of Breguet aircraft p0028 N71 23420

Human factors and control system failures in jet upsets during turbulence encounters p0029 N71 23424

Flying safety factors in close to ground operational design of KH-51 helicopter p0030 N71 23430

Markings for propeller conspicuity [AGARD AR 56] p0057 N74 12713

SAFETY MANAGEMENT  
Safety codes for operators using laser equipment p0076 N72 26057

SANDWICH STRUCTURES  
Development of aerodynamic structural design data to reduce effects of acoustic fatigue on flat and singly curved sandwich panels Part 2 [AGARD AG 162 PT 2] p0090 N73 14898

Application of composite materials and sandwich structures to reduce vulnerability of aircraft structures to projectile impact p0072 N73 27487

Some fatigue characteristics of titanium sandwich structures and numerical analysis of natural frequency and static stress values p0093 N73 29919

SATELLITE ALTITUDE CONTROL  
Satellite altitude control systems NATO conference [AGARD LS 45 71] p0277 N72 12861

Rational dynamics for satellite attitude stabilization p0277 N72 12862

OAO pointing and attitude sensors [NASA TM X 67384] p0277 N72 12863

Passive and semi-active attitude control for flexible satellites p0277 N72 12864

Passive and semi-active attitude control for flexible satellites p0277 N72 12865

Angular momentum exchange systems for attitude control systems and magnetic torquers for active satellite attitude control p0277 N72 12866

Pneumatic system used with TD satellite attitude control system p0278 N72 12868

Servo satellite attitude measurement and control system components p0278 N72 12869

Characteristics of attitude control system and onboard computer used with ANS astronomical satellite for ultraviolet and X-ray measurements in space p0191 N72 19491

Development and characteristics of three axis radio frequency attitude sensor for geostationary satellite p0191 N72 19492

Design development and application of electrically driven flywheels for stabilization of synchronous satellites p0197 N72 19493

Characteristics of sensor system for geostationary spinning satellite to determine satellite attitude during transfer and final orbit p0197 N72 19494

Development of Canopus star sensor for stabilization of X-4 technology satellite p0197 N72 19495

Application of anti-location sensors operating in visible spectra for control of Lincoln Experimental Satellites p0197 N72 19500

Computerized simulation of multi-attitude control system for satellite with flexible booms p0279 N73 23890

SATELLITE CONTROL  
Passive gravity gradient method for stabilization of Pole and Pole satellites p0278 N72 12867

SATELLITE GROUND SUPPORT  
Application of digital computers for automatic testing and data processing during checkout of satellites p0193 N72 19505

SATELLITE INSTRUMENTS  
OAO pointing and attitude sensors [NASA TM X 67384] p0277 N72 12863

Characteristics of satellite television recording system using continuous time scanning with constantly open aperture p0197 N72 19498

SATELLITE NETWORKS  
Orbit sharing and deployment problems of high power satellite communication systems p0133 N73 10205

SATELLITE OBSERVATION  
Satellite fluid level observations for determining radio and radar propagation characteristics p0114 N71 21414

Development of pulse code modulation system for encoding and formatting data using satellite onboard equipment p0193 N72 19503

SATELLITE ORBITS  
Orbit sharing and deployment problems of high power satellite communication systems p0133 N73 10205

SATELLITE ORIENTATION  
Characteristics of sensor system for geostationary spinning satellite to determine satellite attitude during transfer and final orbit p0197 N72 19494

SATELLITE ROTATION  
Rotational dynamics for satellite attitude stabilization p0277 N72 12862

SATELLITE TRACKING  
Analysis of tracking systems used with O-switched laser range finders and application to tracking various satellites p0194 N72 19513

SATELLITE TRANSMISSION  
Amplitude fading of superhigh frequency geostationary communications satellite signals considering atmospheric refraction p0142 N73 26135

## SUBJECT INDEX

## SATELLITE BORNE INSTRUMENTS

Remote satellite microwave sensing of sea surface roughness using water brightness temperature to determine wind fields p0122 N72 18095

## SATELLITE BORNE PHOTOGRAPHY

Analysis of satellite multispectral imagery data for tropical land use interpretation p0124 N72 18111

## SATELLITES

Ionospheric irregularities causing high latitude satellite scintillation p0128 N72 21140

## SCALARS

Laser planogram technique for measuring spatial mixing of passive scalar in turbulent wake p0179 N72 20297

## SCALE (CORROSION)

Transport properties of oxide scales formed on oxidation resistant alloys p0201 N73 23604

Vaporization thermodynamics of C203 protective scales under transonic flow conditions p0202 N73 23607

Oxidation resistant refractory metal alloys for use in high temperature environments p0203 N73 23615

## SCALE EFFECT

Scale effects in flows past swept wings at transonic speeds p0011 N72 11855

Pressure plotting tests on swept wings for analyzing scale effect at high subsonic speeds p0013 N72 11867

Characteristic scales and mixing length methods for determining turbulent boundary layers with mass transfer p0180 N72 20304

## SCALE MODELS

Comparison of wind tunnel and theoretical techniques for determining full scale aerodynamic drag factors [NASA TM X 57413] p0113 N72 11869

Transonic wind tunnel testing requirements for simulating transonic aerodynamic data at flight Reynolds numbers p0014 N72 11873

Coherent approach for calculating backscatter from two scale rough surfaces p0125 N72 18117

Aerodynamic coefficients for calculating transport aircraft performance using wind tunnel and scale models p0053 N73 24046

Modeling methods of determining radar echo characteristics optical ultrasonic and radio methods p0144 N74 11959

Target characteristics radar measurements on scaled models p0144 N74 11960

The propagation of electromagnetic waves over irregular terrain radio wave diffraction and transmission loss p0146 N74 13848

Radar wave diffraction due to a mountain of volcanic origin p0146 N74 13851

## SCALING LAWS

Scaling laws constructional problems and optimum model size associated with wind tunnel tests of helicopters and rotary wing aircraft p0173 N73 28246

## SCATTER PROPAGATION

Tropospheric scatter propagation and prediction of radio transmission characteristics [AGARD CP 70 71] p0117 N71 23451

Tropospheric refractivity variation effects on radio wave scatter propagation p0117 N71 23452

Scanning forward scatter mapping and turbulent layer model for tropospheric scatter propagation analysis p0118 N71 23454

Transmission loss in tropospheric transmission propagation on 12 GHz satellite link p0118 N71 23458

Angular diversity propagation paths of spaced antennas in tropospheric transmission scatter link p0118 N71 23459

Formulas for calculating depolarization effects on double polarization in statistically homogeneous and isotropic dielectric constant medium p0119 N71 23460

Ultrahigh frequency antenna scatter propagation distribution by vegetation p0119 N71 23461

Maxwell field theory for solving wave path controllability in tropospheric scatter propagation p0119 N71 23462

Multipath transmission models for predicting signal distortion and intermodulation in tropospheric scatter propagation p0119 N71 23463

Mathematical model for frequency correlation functions of tropospheric scatter channel p0119 N71 23464

Frequency correlation measurements on multipath tropospheric scatter propagation p0119 N71 23465

Impulse response measurements and radio test link for evaluating tropospheric scatter propagation channel capacity p0119 N71 23466

Computerized simulation of tropospheric scatter channel distortion using Monte Carlo method p0119 N71 23467

Statistical forecast of signal attenuation with tropospheric scatter using meteorological parameters p0120 N71 23471

Side scatter propagation at higher frequencies for monitoring air pollution using remote optical radar and laser altimetry p0172 N72 18097

Measurements of precipitation scatter at 13.6 GHz p0147 N74 13855

## SCATTERING FUNCTIONS

Light scattering by particles in sea water based on volume scattering function and point spread function p0242 N73 33628

## SCHEDULING

Man machine approach toward solving various scheduling and network problems p0154 N72 11199

## SCHLIEREN PHOTOGRAPHY

Mathematical models and numerical analysis of coherent optical systems used as holographic schlieren system p0199 N72 25498

High speed schlieren film of pulsating flow in transonic turbine cascade p0211 N73 19818

## SCHOOLS

Organization and operation of US Air Force Test Pilot School p0038 N72 20894

Procedures for training pilots in assessment of flight systems during attendance at Empire Test Pilot School England p0036 N72 20995

Organization operation and curriculum of U.S. Navy Test Pilot School at Patuxent Naval Air Station Maryland p0037 N72 20996

## SCIENTIFIC SATELLITES

Development and characteristics of data storage equipment for use on small scientific spacecraft p0193 N72 19502

## SCINTILLATION

High latitude studies of scintillation in radio signals from radio sources and satellites p0128 N72 21137

Intensity variations in satellite scintillations in F region p0128 N72 21138

Ionospheric irregularities causing high latitude satellite scintillation p0128 N72 21140

HF auroral backscatter scintillation theory and satellite beacon recordings p0130 N72 21150

The effect of the August 1972 magnetic storms on scintillation p0187 N74 14088

## SCREENING

Effect of terrain screening on the different mechanisms of propagation p0146 N74 13850

## SE 210 AIRCRAFT

Automatic approach and landing system with flash warning signal for Caravelle aircraft control p0070 N71 23429

A new approach to gust alleviation of a flexible aircraft using an open loop device application to control system of SE 210 aircraft p0060 N74 17745

## SEA ROUGHNESS

Narrow pulse width radar system for measuring ocean wave heights p0122 N72 16094

Remote satellite microwave sensing of sea surface roughness using water brightness temperature to determine wind fields p0122 N72 16095

Geometrical optics theory for microwave brightness temperatures in rough sea surface emissivity for remote sensing data interpretation p0124 N72 16112

## SEA STATES

Radar sea clutter sea state effects on cross sectional echo characteristics p0145 N74 11962

## SEA WATER

Pre-cracked cantilever beam and long term beam exposure tests for determining stress corrosion of Al alloys in sea water p0288 N72 21919

Proceedings of conference on electromagnetic and optical properties of sea water for application to surveillance mapping communications and visibility p0241 N73 33619

Debye polarization theory for determining electromagnetic wave propagation in sea p0241 N73 33622

Optical properties of pure and turbulent sea water p0241 N73 33624

Techniques for predicting effects of thermal and saline inhomogeneities on optical imaging systems with application to optical properties of sea water p0241 N73 33625

Effect of ocean depth on light scattering and attenuation parameters to include optical properties influenced by concentration size and shape of particulate matter p0241 N73 33626

Mathematical theories for determining light propagation by sea water p0241 N73 33627

Light scattering by particles in sea water based on volume scattering function and point spread function p0242 N73 33628

Effect of various parameters on long range underwater vision for narrow and broad beam illumination p0242 N73 33630

Effects of resolution signal to noise ratio and contrast on underwater imaging systems performance p0242 N73 33631

Computer programs for analyzing optical properties of sea water p0243 N73 33638

## SEARCH PROFILES

Robot data screening process to select relevant variables in data search p0151 N72 11176

## SEAT BELTS

Safety belts and air bags for highway accident prevention p0099 N72 19126

Airbag and seat belt and air bag testing in various mine European car collisions p0099 N72 19130

## SECONDARY FLOW

Experiments with cascade secondary flows p0270 N73 19811

## SECONDARY INJECTION

Performance predictions for turbine blade film cooling with injection through holes p0259 N71 17388

## SELECTIVE DISSEMINATION OF INFORMATION

Harwell heat transfer and fluid flow information analysis center p0113 N71 19530

Profile construction cost benefits economics and user surveys in transfer of technology and selective dissemination of information p0301 N71 23506

Design and operational services of small data centers to technical users [AGARD CP 117] p0158 N73 24201

Information dissemination services to industry p0159 N73 24210

Information dissemination services of technical information service of National Research Council of Canada p0159 N73 24211

## SELF ADAPTIVE CONTROL SYSTEMS

Problems in application of adaptive and self organizing algorithms for pattern recognition p0152 N72 11185

## SELF ALIGNMENT

Advanced procedures for self alignment and calibration of mental platforms p0230 N73 20708

## SEMANTICS

Question answering system DELFI for automatic generation of programs to express semantic content of English like sentences in procedural intermediate language p0151 N72 11177

## SEMICIRCULAR CANALS

The motoneuric stimulation of the labyrinth by Peltier regulated ear canal plug p0109 N74 20748

## SEMICONDUCTOR DEVICES

Development of system for improved quality control of semiconductor devices used in design of spacecraft electronic equipment p0151 N72 19481

Application of scanning electron microscopy for failure analysis and nondestructive tests of semiconductor devices p0191 N72 19488

## SEMICONDUCTORS (MATERIALS)

Application of complementary metal oxide semiconductor to design of integrated circuits used with spacecraft electronic equipment and commercial equipment p0191 N72 19486

## SEMIEMPIRICAL EQUATIONS

Semiempirical methods for designing ejectors for various applications p0183 N73 17252

## SENSORIMOTOR PERFORMANCE

Relationship of interaction of impulsiveness and anxiety to perceptual motor performance in human beings p0069 N71 20361

## SENSORY DEPRIVATION

Effects of education and pharmacodynamics on adaptability of human beings to degraded sensorial environments p0069 N71 20364

## SENSORY PERCEPTION

Sensory factors of motion vision and hearing for piloted flight simulation p0171 N71 16064

## SEPARATED FLOW

Flow separation concepts under high lift conditions p0025 N71 20055

Representations of flow separation bubbles near airfoil leading edge p0027 N71 20064

Analysis of laminar part of separation bubbles in two dimensional incompressible flow for various shaped objects p0041 N73 15000

Development of method for calculating small separation zones near leading edge of airfoil at incidence p0041 N73 15002

Influence of various aerodynamic forces on rectangular wing performance with harmonic movement parallel to free flow movement p0050 N73 11043

Drag and separation effects of separated flow on aerodynamic drag p0020 N74 14722

A study of flow separation in the base region and its effects during powered flight interaction between propulsive jet and free stream flow p0020 N74 14724

The drag resulting from three dimensional separations caused by boundary layer diverters and nacelles in subsonic and supersonic flow p0021 N74 14728

## SEPARATORS

Dual purpose filter separators for dust and water removal from fuel p0257 N72 11676

## SEQUENTIAL COMPUTERS

Serial digital data bus for integrated avionics system interface p0281 N73 23902

## SEQUENTIAL CONTROL

Monte Carlo simulation for man machine task sequencing considering pilot performance degradation p0280 N73 23899

## SERVICE LIFE

Hybrid microelectronic technology for spacecraft electronic equipment to improve reliability and service life p0191 N72 19485

Development of procedures for predicting fatigue life of aircraft structures based on fracture mechanics crack propagation and residual static strength analysis [AGARD LS 62] p0294 N73 23924

Development of fatigue life prediction procedures based on accelerated stress time histories and mathematical model for description of crack growth dynamics p0294 N73 23926

Procedures for predicting fatigue life of aircraft flying under various load conditions from data obtained by counting accelerometer p0294 N73 23927

Effect of environment and stress cycling on in-service structural failure of airframes and procedures for predicting safe operational conditions p0295 N73 29929  
The role of the major fatigue test in the acceptance certification and safe utilization of strike aircraft p0061 N74 19658

**SERVOCONTROL**

Servocontrol infrared optometer applied to study of volitional control of human visual accommodation [NASA TM X 68955] p0070 N71 20371

**SERVO MECHANISMS**

Flight test of three axis hydrodynamic stability augmentation system in helicopter p0034 N72 11937

**SHEAR FLOW**

Turbulent boundary layers jets and wakes conferences [AGARD CP 93] p0175 N72 20273

Turbulent shear flow model for asymmetric free jet two dimensional free shear layer and flat plate boundary layer [NASA CR 125904] p0177 N72 20285

Flow visualization techniques and hot wire anemometer data for shear flow turbulence p0178 N72 20290

Physical structure of turbulent shear flows in nonreacting gas flow [AGARD AR 46] p0182 N73 11262

**SHEAR LAYERS**

Complex turbulent flows as perturbations of classical thin shear layers and application of Prandtl approximation p0175 N72 20274

Stabilization of turbulent shear layer flow in rotating systems by Coriolis forces p0180 N72 20305

**SHEAR STRESS**

Improved mixing length model applied to three dimensional boundary layer assuming turbulent shear stress in same direction as laminar p0177 N72 20284

Turbulent shear stress models resulting from classical Prandtl mixing theory to kinetic energy models p0178 N72 20291

Application of transport equation to Reynolds shear stress to calculating two dimensional flow in turbulent flow shear layers p0179 N72 20298

**SHELLS (STRUCTURAL FORMS)**

Homologous deformation of stiffened shell for radio telescope structures p0298 N74 15616

**SHIELDS**

Health hazards and efficiency reductions of personnel exposed to simulated nuclear shock waves in protective shelters p0100 N72 19138

**SHIPS**

Satellite communication terminal for ships p0133 N73 10204

Determination of ships orientation from accelerometer signals p0230 N73 20703

Analysis of procedures and problems involved in operating helicopters from decks of ships p0048 N73 21010

**SHOCK DISCONTINUITY**

Numerical analysis of viscous gas flow and shock formation p0181 N72 27300

**SHOCK LOADS**

Feasibility of transonic wind tunnel testing of large cord swept wing panel model for simulating wing shock location at flight Reynolds number [NASA TM X 67414] p0013 N72 11870

**SHOCK TUNNELS**

Comparison between conventional blowdown and Ludwig tube driven transonic wind tunnels for high Reynolds number range p0015 N72 11881

Performance and operational characteristics of high Reynolds number blowdown and shock wind tunnels for transonic model testing p0016 N72 11884

Measurement of drag in a shock tunnel p0023 N74 14738

**SHOCK WAVE GENERATORS**

Auroral infrasonic shock wave generation by supersonic electrojet arcs p0135 N73 14137

Acoustic gravity wave generation by transient sources in isothermal atmosphere p0135 N73 14139

**SHOCK WAVE INTERACTION**

Interaction of shock wave with turbulent boundary layer at moderate supersonic Mach numbers p0271 N73 19815

Shock wave boundary layer interaction in compressor cascades p0271 N73 19818

**SHOCK WAVE PROPAGATION**

Acoustic gravity wave propagation modes in ionosphere and neutral atmosphere following nuclear explosion [CONTRIB 1799] p0135 N73 14140

Infrasonic wave generation and atmospheric propagation of gravity acoustic waves p0136 N73 14142

Excitation of Lamb atmospheric edge mode by tail of large atmospheric explosion p0136 N73 14143

Hydrodynamic calculations and experimental observations of ionospheric shock front propagation following nuclear explosion p0137 N73 14153

Continuous wave Doppler radar observations of ionospheric disturbances generated by Saturn Apollo launchings p0138 N73 14157

Infrasonic detection of propagating atmospheric shock waves caused by supersonic aircraft p0138 N73 14161

**SHOCK WAVES**

Computation of one dimensional shocked flow p0181 N72 27301

Computation of transonic inviscid flow with embedded shock waves p0182 N72 27305

Effect of surface pressure fluctuations on response of panels underlying attached and separated turbulent boundary layers and shock waves p0292 N73 29910

Survey of computational methods for three dimensional supersonic inviscid flows with shocks p0185 N74 22919

A survey of computational methods for 2D and 3D transonic flows with shocks p0185 N74 22920

**SHORT HAUL AIRCRAFT**

Rational calculation of design gust loads in relation to present and proposed airworthiness requirements effects of atmospheric turbulence on aerodynamic configuration of short haul aircraft p0059 N74 17740

**SHORT RANGE BALLISTIC MISSILES**

Design optimization of SRAM inertial navigation and guidance p0230 N73 20705

**SHORT TAKEOFF AIRCRAFT**

Flight testing military transport aircraft for handling and performance in STOL applications p0026 N71 20060

Lift augmentation devices effect on STOL engine Part 1. Interface problems between engine and airframe p0026 N71 20061

Lift augmentation devices effect on STOL engine Part 2. Thermodynamic problems p0026 N71 20062

Optimizing propulsive lift system for turboprop STOL aircraft considering cost effectiveness p0026 N71 20063

Accident investigations flight control systems and operational findings for improved aircraft flight mechanics [AGARD CP 76 71] p0027 N71 23410

Design modifications on short takeoff Bronco aircraft resulting from combat operations tests p0028 N71 23416

Operational performance and handling safety requirements for single engine boundary layer controlled aircraft in STOL mode p0028 N71 23419

Augmentor flap wing ducting and augmentor nozzle and noise reduction for jet STOL aircraft [NASA CR 125540] p0284 N72 16696

Analysis of factors affecting lateral directional handling qualities of aircraft during short takeoff flight p0040 N72 32033

Development of jet flap rotor and application to heavy helicopter and stopable rotor designs p0048 N73 21025

Analysis of short takeoff and landing aircraft landing guidance systems and application of air traffic control procedures for improved sequencing p0233 N73 23703

Methods for evaluating and predicting airfield performance of turbojet and turboprop aircraft operating in conventional and short takeoff modes p0053 N73 24044

Flight tests for determining handling qualities and operational characteristics of Breguet 941 STOL aircraft p0054 N73 27008

Propulsive lift technology program for development of short takeoff aircraft propulsion systems and lift augmentation devices p0055 N73 27009

Design development and evaluation of Buffalo Sove Augmentor wing research aircraft using internally blown flap for lift augmentation p0055 N73 27010

Design development and requirements for short takeoff transport aircraft for military applications using civil aircraft production procedures p0055 N73 27011

Analysis of aerodynamic characteristics affecting selection of short takeoff transport aircraft p0055 N73 27012

Analysis of research and development programs involving construction of short takeoff transport aircraft in Germany p0055 N73 27013

Aerodynamic characteristics of high lift wing concepts for application to commercial short takeoff transport aircraft p0292 N73 29908

The effect of gusts and wind shear for automatic STOL approach and landing simulation and flight test of flight control system for short takeoff aircraft p0058 N74 17730

Data requirements on turbulence in the earth's atmosphere for STOL design criteria development of low altitude gust model for determining importance of gust parameters on STOL aircraft performance p0059 N74 17737

**SIDE LOOKING RADAR**

Conference on propagation ranges of microwave infrared and photographic remote sensing systems for pollution detection and sea state roughness measurements [AGARD CP 90 71] p0121 N72 16085

Interpretation of side looking airborne radar imagery for vegetation mapping [NASA CR 125451] p0122 N72 16092

**SIDELobe REDUCTION**

Introductory survey to session 3 Control of antenna side lobes p0147 N74 13857

Some aspects of near and far angle sidelobe in double reflector antennas p0147 N74 13858

Synthesis of aperture distributions for optimum gain with noise and interference rejection p0147 N74 13860

**SIGNAL ANALYSIS**

Signal analysis and computer graphics for signal classification systems p0154 N72 11201

Multiple coding method for analyzing radiation distribution in infrared imagery signal p0175 N72 16114

**SIGNAL DETECTION**

Kalman filtering algorithm for detecting continuous wave interference signals in digital telecommunications p0133 N73 10213

**SIGNAL DETECTORS**

Digital receiver for detecting moderate data rate phase shift keyed signals in real time p0132 N73 10196

**SIGNAL DISTORTION**

Computerized simulation of tropospheric scatter channel distortion using Monte Carlo method p0119 N71 23467

Scattering and attenuation of remote infrared imaging instrument signals during atmospheric propagation p0123 N72 16104

Monte Carlo calculation on error probability distribution in sensing systems caused by refractive index of sensed medium p0125 N72 16115

**SIGNAL FADING**

Tropospheric characteristics and their effects on electromagnetic wave propagation and radio signal transmission [AGARD CP 70 71 PT 1] p0114 N71 21409

Very high frequency signal fading in diffraction scatter path propagation p0117 N71 21431

Statistical evaluation of fading caused by intermodulation in combined long wave broadband propagation [CNET NT EST, APH 1] p0117 N71 21433

Atmospheric calculation model for analyzing tropospheric ultrahigh frequency signal fading p0118 N71 23456

Analysis of amplitudes and frequencies of signal fading in satellite to aircraft radio links due to multiplexing of radio signals p0194 N72 19509

Nonisothermal random polarization of electromagnetic wave in ultrahigh frequency radio link p0140 N73 26123

Multipath propagation and phase delay of ultrahigh frequency radio wave caused by atmospheric discontinuity p0140 N73 26124

Rain attenuation and multipath fading in ultrahigh frequency radio relay systems p0142 N73 26134

Point rainfall rate statistics for predicting ultrahigh frequency radio propagation p0142 N73 26136

Calculation of electromagnetic wave absorption by rain for frequencies close to 30 GHz p0142 N73 26138

Amplitude fading of superhigh frequency geostationary communications satellite signals considering atmospheric refraction p0142 N73 26139

Slant path attenuation of ultrahigh frequency signals from sun tracking radionetters p0142 N73 26140

Thunderstorm cloud height and fading statistics for AT5 5 ultrahigh frequency signal transmission to earth p0142 N73 26141

Effects of rain and atmospheric turbulence on ultrahigh frequency space communication radio line p0143 N73 26143

Tropospheric influence on the screening effect due to a mountain ridge on 3 GHz radio transmission loss due to atmospheric refractivity p0146 N74 13853

**SIGNAL PROCESSING**

Processing and display of time varying spectral information with application to sonar voice and medical signals p0154 N72 11200

Fast Fourier transform digital processor as spectrum analyzer and adaptive filter p0137 N73 10198

**SIGNAL RECEPTION**

Fundamental concepts of communication theory to include transmission of continuous signals and use of discrete time signals p0143 N73 32054

**SIGNAL REFLECTION**

Tropospheric characteristics and their effects on electromagnetic wave propagation and radio signal transmission [AGARD CP 70 71 PT 1] p0114 N71 21409

Radio reflectivity calculations for tropospheric elevated layers during transhorizon propagation p0116 N71 21424

Mathematical model for partial reflection from tropospheric layer in radio transhorizon propagation p0118 N71 21457

**SIGNAL TO NOISE RATIOS**

Calculation of diffraction efficiency and signal to noise ratio for two dimensional and volume diffuse signal beam holograms p0199 N72 25500

Signal to noise ratio performance of optimum digitalized FM demodulator p0131 N73 10195

Attenuation and phase constancy propagation criteria of tactical satellite communications using mobile ground terminal p0132 N73 10201

Effect of resolution signal to noise ratio and contrast on underwater imaging systems performance p0242 N73 33631

Method for comparing photo electronic and photographic detectors based on product of signal to noise ratio times signal bandwidth p0242 N73 33634

The use of target and clutter for different methods of discrimination between targets and unwanted clutter processing of incoherent video and coherent radar signals p0145 N74 11963

**SIGNAL TRANSMISSION**

Application of chip modulation to improve effectiveness of satellite to aircraft communications p0194 N72 19514

Propagation loss spectral spreading and temporal spreading of high altitude HF signal transmission p0129 N72 21144

**SIGNATURE ANALYSIS**

Range Echoless class of flying animals p0144 N74 11961

**SIGNS AND SYMPTOMS**

Application of psychotherapy in aviation psychiatry for treatment of syndromes of reactive nature p0059 N73 20365

**SILICON**

Bonded, polished, and etched silicon substrate resistant to high temperature, high voltage, and high frequency vehicles p0201 N73 23516

# SUBJECT INDEX

## SILICON DIOXIDE

- Elastic properties and testing methods of organic matrix composites and the fabrication and interface problems of beryllium aluminum composite matrix conference [AGARD CP 67 71] p0206 N72 12492
- Mechanical properties of silica fiber reinforced epoxy composite materials p0207 N72 12493
- Ultrasonic measurements on silica epoxy and silica phenolic sheets in liquid filled tank p0207 N72 12494
- Elastostatic measurements of elastic modulus on resin fiber composite materials p0207 N72 12495
- Linear and nonlinear stress characteristics of epoxy silica composite materials p0207 N72 12496
- Theoretical and experimental determination of elastic constants in silica epoxy composite materials p0207 N72 12497
- Temperature and fiber orientation effects on mechanical behavior of silicon dioxide epoxy composite materials p0207 N72 12499

## SIMULATION

- Simulated crash tests to assess the resistance of aircraft fuselages containing polymeric additives p0254 N72 11692
- Guided sled apparatus for simulation of automobile collisions p0103 N72 19152
- Linear and angular acceleration terminology human acceleration simulation airplane airbag restraint systems and mathematical models of automobile crash loads p0103 N72 19155
- Simulation of frontal collisions and injuries sustained by cadavers using safety belts and air bags p0104 N72 19159
- Simulation and investigation of scattering mechanisms of radio aurora p0228 N72 21135

## SIMULATORS

- Development of procedures for exposing aviators to effects of spatial disorientation in ground based simulator p0073 N72 25045

## SINGULARITY (MATHEMATICS)

- Singularity method for calculating incompressible flow through cascades with separation p0269 N73 19802

## SIRENS

- Application of siren as test technique for determining response and life of aircraft structures subject to engine noise field excitation p0294 N73 29922

## SIRIO SATELLITE

- Sirio satellite attitude measurement and control system components p0278 N72 12869

## SKIN (ANATOMY)

- Structural and mechanical characteristics of human connective tissue p0101 N72 19140

## SKIN (STRUCTURAL MEMBER)

- Acoustic fatigue tests of aluminum alloy structural elements under narrow band random loading with zero mean stress in skin p0294 N73 29921

## SKIN FRICTION

- Review of drag measurements from flight tests of manned aircraft with comparisons to wind tunnel predictions p0022 N74 14735

## SKY WAVES

- Ionospheric disturbance effects on sky wave bearing measurement p0138 N73 14159

## SLEDS

- Guided sled apparatus for simulation of automobile collisions p0103 N72 19152

## SLEEP DEPRIVATION

- Pilot performance and sleep patterns in long duration flights and control of hypnosis drug and alcohol use p0080 N73 21107

## SLENDER WINGS

- Wind tunnel measurements of Reynolds number effect on force and pressure coefficients for slender delta wing at transonic speed p0012 N72 11863
- Comparison of transonic wind tunnel test data with flight test results on slender wing airplanes for double delta configuration development p0013 N72 11868
- Comparison of flight test and wind tunnel data to determine areas of agreement when nonlinearities appear in aerodynamic coefficients of slender wing aircraft p0036 N72 20990

## SLOTTED WIND TUNNELS

- Design of vented walls for transonic wind tunnels with analysis of parameters affecting noise generation p0184 N73 26281

## SMOKE

- Influence of altitude and drugs on cerebral circulation in smokers and non smokers p0082 N73 21125
- Smoke suppressant additive effects on particulate emission from gas turbine combustors p0221 N74 14305

## SOCIAL PSYCHiatry

- Clinical psychology and psychology of the aerospace operational environment p0088 N74 18720
- Influence of social interaction factors on crew performance: A systems of social approach p0089 N74 18723

## SODIUM

- Sodium and magnesium in the combustion of solid fuels p0202 N73 23619

## SOIL MOISTURE

- Ground content of soil by the reflectance from a light p0218 N74 14283

## SOLAR ACTIVITY EFFECTS

- Relationship between atmospheric gravity waves and spread F conditions caused by solar activity p0136 N73 14146

## SOLAR CORONA

- Application of complementary MOS circuits in pulse code modulation systems for photogrammetry of X ray region of solar corona and in operation of quartz clock with PCM output p0192 N72 19501

## SOLAR ENERGY

- Influence of solar energy absorption and air water interactions on seasonal thermocline of sea p0241 N73 33823

## SOLAR RADIO EMISSION

- Solar radio interferometry for traveling ionospheric disturbance detection p0138 N73 14158

## SOLID LUBRICANTS

- Feasibility analysis of solid lubricated ball bearings for aircraft propulsion systems application p0255 N72 11700

## SOLID STATE DEVICES

- Development and characteristics of microelectronic equipment for improved reliability and reduced weight and size of electronic components p0191 N72 19484
- Solid state electroluminescent materials for display devices p0225 N72 22638
- Display principle for 3 D or multiplexor solid state 2 D panel displays p0225 N72 22640
- Characteristics of solid state ruby laser and application for holographic recording p0200 N72 25502
- Application of solid state switching multiplexing and electrically programmable logic to aircraft electrical systems p0066 N73 19053
- Development of electrical generation and distribution systems for supersonic aircraft using solid state switching and remote control of protective devices p0086 N73 19054

## SONAR

- Processing and display of time varying spectral information with application to sonar voice and medical signals p0154 N72 11200

## SONIC NOZZLES

- Velocity distribution measurement of subsonic axisymmetric inlet for compressor matching p0267 N72 10714

## SOOT

- Soot formation in which kernels are formed at high pressure p0219 N74 14289
- Soot oxidation kinetics at combustion temperatures p0219 N74 14290

## SOUND FIELDS

- Sound field generation by transonic flow over perforated surface liners in wind tunnels p0014 N72 11876

## SOUND GENERATORS

- Sound field generation by transonic flow over perforated surface liners in wind tunnels p0014 N72 11876
- Application of siren as test technique for determining response and life of aircraft structures subject to engine noise field excitation p0294 N73 29922

## SOUND TRANSMISSION

- Fundamentals of helicopter noise generation and propagation for blade noise control procedures and just effective noise reduction p0017 N73 22953

## SOUND WAVES

- Conference on acoustic gravity wave effects in atmospheric transmission and radio communication systems [AGARD CP 116] p0134 N73 14131
- Comparison of atmospheric radio wave propagation with acoustic gravity wave propagation p0134 N73 14132
- Acoustic-gravity sound wave generation and downward propagation into lower atmosphere p0134 N73 14134
- Effects of acoustic gravity wave diffraction on atmospheric boundaries p0135 N73 14136
- Acoustic gravity wave generation by transient sources in the lower atmosphere p0135 N73 14139
- New acoustic-gravity wave propagation phenomena in the atmosphere p0135 N73 14141
- Excitation of transverse atmospheric gravity waves by large atmospheric explosions p0136 N73 14143
- For space exploration as caused by infrasonic waves propagation from the ground p0136 N73 14148
- Electromagnetic propagation of low frequency low frequency propagation techniques for measuring atmospheric gravity waves in the upper atmosphere p0137 N73 14153
- Nonlinear propagation of atmospheric gravity waves of atmospheric waves following nuclear explosions p0140 N73 14168

## SOUNDING ROCKETS

- Testing of an altitude control system for sounding rockets p0136 N74 14149

## SPACE COMMUNICATION

- Experiments in timing and delay effects on electromagnetic wave propagation in space communication systems p0134 N73 14143
- Measurements of the fall afterglow of an ionospheric wave height p0134 N73 14145
- Optimization of a communication system and propagation parameters for space communication p0135 N73 14147

# SPACECRAFT COMMUNICATION

- Development of multi beam antenna system and combiner switch for producing variable coverage radiation pattern for satellite communication system p0193 N72 19507

- Design development and characteristics of telecommunication links using HELIOS space probe as example p0194 N72 19508

- Analysis of amplitudes and frequencies of signal fading in satellite to aircraft radio links due to multiplexing of radio signals p0194 N72 19509

- Facilities and techniques for measuring antenna radiation patterns of spacecraft telemetry and telecommand antennas p0194 N72 19512

- Application of chirp modulation to improve effectiveness of satellite to aircraft communication p0194 N72 19514

- Conference on expanded aerospace telecommunication system requirements and digital data transmission methods [AGARD CP 103] p0130 N73 10187

- Digital telecommunication techniques and network planning for aerospace systems p0131 N73 10188

- Noise and error effects on differential pulse code modulation transmission of sampled aerial imagery p0131 N73 10190

## SPACE FLIGHT

- BIOSTACK experiment on Apollo 16 for studying combined action of heavy high energy loss nuclear and space flight factors on resting biological systems p0083 N73 23062

## SPACE GLOSSARIES

- AGARD Glossary of Aerospace Medical Terms [AGARD AG 153 71] p0067 N71 20076

## SPACE MISSIONS

- Development and operation of programmable PCM telemetry encoder for data storage and processing during space missions p0193 N72 19504

## SPACE NAVIGATION

- Proceedings of conference on inertial navigation components and systems with emphasis on concepts and techniques involving cost and performance tradeoffs [AGARD CP 116] p0227 N73 20684

- Testing philosophy and methods of guidance and control systems and subsystems applied to navigation systems for a craft spacecraft and missiles p0236 N74 14345

## SPACE PROBES

- Characteristics of solid state power amplifiers for direct amplification using GaAs and InP devices p0194 N72 19510

## SPACE SHUTTLES

- Hot gas stress corrosion cracking of titanium alloys used as radiative heat shields in space shuttles [NASA TM X 68304] p0289 N72 21926

- Proceedings of conference on inertial navigation components and systems with emphasis on concepts and techniques involving cost and performance tradeoffs [AGARD CP 116] p0227 N73 20684

- Operational cost and technological development aspects in design of space shuttle avionics systems p0278 N73 23884

- Simulation model for optimum spaceborne computer system design controlling shuttle boosters subsystems p0279 N73 23891

- Onboard computer system for in flight monitoring of space shuttle in support of flight crew p0280 N73 23893

- Onboard design analysis system for a space shuttle design p0298 N74 15613

## SPACE VEHICLE CHECKOUT PROGRAM

- Development of wiring data system for performing checkout of space launchers and aircraft systems p0191 N72 19489

## SPACEBORNE ASTRONOMY

- Characteristics of attitude control system and onboard computer used with ANS astronomical satellite for ultraviolet and X ray measurements in space p0191 N72 19489

## SPACEBORNE PHOTOGRAPHY

- Application of complementary MOS circuits in pulse code modulation systems for photogrammetry of X ray region of solar corona and in operation of quartz clock with PCM output p0192 N72 19501

## SPACECRAFT ANTENNAS

- Facilities and techniques for measuring antenna radiation patterns of spacecraft telemetry and telecommand antennas p0194 N72 19512

## SPACECRAFT COMMUNICATION

- Ionospheric attenuation of low frequency satellite signals at 15 to 20 Mc wave lengths p0135 N73 14141

- Attenuation and phase of steady propagation in medium of high latitude ionospheric layers using the full ground ionospheric p0137 N73 14153

- Weather related to satellite communication systems using optical processing p0132 N73 14140

- Measure and methods and error analysis by ground receivers for satellite communication p0131 N73 10187

- Satellite communication and terminal for ships p0131 N73 10187

- Onboard timing and delay effects on electromagnetic wave propagation in space communication systems p0134 N73 14143

- Measurements of the fall afterglow of an ionospheric wave height p0134 N73 14145

- Optimization of a communication system and propagation parameters for space communication p0135 N73 14147



## SPACECRAFT COMPONENTS

### SPACECRAFT COMPONENTS

Spin satellite attitude measurement and control system components p0278 N72 12869

### SPACECRAFT CONTROL

Feasibility of automated spacecraft monitoring using real time computer telemetry p0279 N73 23888

Mathematical models for human performance in manned spacecraft control p0280 N73 23897

### SPACECRAFT DESIGN

Application of a design analysis system to a space shuttle preliminary design p0298 N74 15613

### SPACECRAFT ELECTRONIC EQUIPMENT

Models for determining failure modes and stress limits of spacecraft equipment p0190 N71 36782

Proceedings of conference on avionics in spacecraft covering component technology, instrumentation, satellite subsystems, and satellite systems p0190 N72 19483

Hybrid microcircuit technology for spacecraft electronic equipment to improve reliability and service life p0191 N72 19485

Application of complementary metal oxide semiconductor to design of integrated circuits used with spacecraft electronic equipment and commercial equipment p0191 N72 19486

Development of system for improved quality control of semiconductor devices used in design of spacecraft electronic equipment p0191 N72 19487

Application of scanning electron microscopy for failure analysis and nondestructive tests of semiconductor devices p0191 N72 19488

Characteristics of electronically operated mass spectrometer for satellite applications and analysis of atmospheric data acquisition p0192 N72 19494

### SPACECRAFT GUIDANCE

Software and hardware technology for application of computer systems to guidance and control of aerospace vehicles [AGARDograph 158] p0155 N72 21211

Hardware organization and system design of guidance and control computers p0155 N72 21214

Programming characteristics of future guidance and control computers p0156 N72 21216

Fault isolation capabilities for general purpose digital computer used in guidance and control applications p0156 N72 21220

### SPACECRAFT INSTRUMENTS

Proceedings of conference on avionics in spacecraft covering component technology, instrumentation, satellite subsystems, and satellite systems [AGARD CP 87 711] p0190 N72 19483

### SPACECRAFT LAUNCHING

Continuous wave Doppler radar observations of ionospheric disturbances generated by Saturn Apollo launches p0179 N73 14157

### SPACECRAFT POSITION INDICATORS

Characteristics of sensors for spacecraft attitude determination by reference to earth horizon in visible and infrared spectra p0192 N72 19495

### SPACECRAFT STRUCTURES

Proceedings of conference on application of composite materials in construction of aerospace vehicles and propulsion systems [AGARD CP 112] p0210 N73 27474

Design and manufacturing of composite materials with organic matrices for use in aerospace vehicle structures subjected to high temperatures p0212 N73 27489

Development of fiber reinforced composite materials for application to air breathing engines, aeronautical vehicles, and spacecraft components p0212 N73 27491

### SPATIAL DISTRIBUTION

Multiplex coding method for analyzing radiation distribution in infrared imagery signal p0125 N72 16114

Laser planogram technique for measuring spatial mixing of passive scalar in turbulent wake p0179 N72 20297

Spatial correlation of auroral radio absorption using nomograms p0129 N72 21146

Merisium and Macloin under double blind comparison test conditions against motion sickness p0079 N73 21100

Method for comparing photo electronic and photographic detectors based on product of signal to noise ratio times spatial bandwidth p0242 N73 33634

### SPECTRAL REFLECTANCE

Multispectral reflectivity curves in near infrared and visible regions for planning remote multi band terrain photography p0124 N72 16109

### SPECTRUM ANALYSIS

Variable coefficient in parabolic equation of diffusion for analyzing inhomogeneous media through magnetic field penetration spectra p0125 N72 16118

Temperature fluctuations and spectral distributions for temperature and velocity in turbulent boundary layer p0175 N72 20276

### SPEECH RECOGNITION

Operational description of two different systems for automatic speaker recognition p0151 N72 11179

Structural vibration and noise effects on man in aerospace operations [AGARDograph 151] p0076 N73 17098

Noise effects on hearing concentration in aircrew and ground support personnel of aerospace operations p0077 N73 17101

### SPHERES

A review of supersonic sphere drag from the continuum to the free molecular flow regime p0022 N74 14732

### SPIN DYNAMICS

Rotational dynamics for satellite attitude determination p0277 N72 12862

### SPIN STABILIZATION

Satellite attitude control systems NATO conference [AGARD LS 45 71] p0277 N72 12861

Passive and semi active attitude control for multiple spin satellites p0277 N72 12864

### SPINE

Necropsy and radiographic observation of spinal fracture and articular facet derangement patterns in rhesus monkeys [AMRL TR 71 17] p0101 N72 19139

Radiological observations of spinal injuries to pilots caused by sudden ejection p0102 N72 19148

Radiological spinal examination of combat pilots and limiting angle for scoliosis p0074 N72 25056

Andrew's fitness for flying duties after vertebral fractures and spinal surgery p0086 N74 13794

### SPREAD F

Relationship between atmospheric gravity waves and spread F conditions caused by solar activity p0136 N73 14 15

### STABILITY DERIVATIVES

Analysis of factors in stall and post stall operating conditions and effect on aircraft configurations p0039 N72 32029

Analysis of stall and post stall characteristics of F 111 aircraft and development of regression techniques to obtain aerodynamic derivatives p0043 N73 15013

### STABILIZATION

Breakdown of automatic pilots or auxiliary stabilization systems on helicopters p0031 N72 11918

Design of stability augmentation system for WG13 ngd rotor helicopter p0033 N72 11930

System for increasing helicopter stability p0033 N72 11932

Fight test of three axis hydrofluidic stability augmentation system in helicopter p0034 N72 11937

Design development and application of electrically driven flywheels for stabilization of synchronous satellites p0192 N72 19493

C.S.A.S. design for good handling in turbulence development of design criteria for stability augmentation systems for alleviation of gust effects p0059 N74 17741

### STABILIZED PLATFORMS

Numerical analysis of effects of various parameters affecting accuracy and stability of strapdown inertial navigation systems p0227 N73 20685

Research activities of electronic laboratory in development of inertial navigation systems to include applications for space missions and commercial aviation p0227 N73 20686

Development and evaluation of failure detection and isolation technique for use with four gimbaled inertial measuring units p0228 N73 20687

Development of single degree of freedom gyroscope for application to strapdown inertial guidance system p0228 N73 20688

Methods for conducting acceptance tests and reliability tests of gyroscopes as part of inertial platform quality control procedures p0228 N73 20689

Development of low cost inertial measurement unit with navigational accuracy performance based on optimum size design of inertial instruments and platform p0228 N73 20690

Optimization of integrated navigation systems combining several independent navigation sensors to provide self contained aircraft navigation capability p0229 N73 20694

Three axis gyro stabilized torpedoes platform p0230 N73 20702

Application of cluster rotation to improvement of existing platforms in strike aircraft p0230 N73 20704

Testing philosophy and methods of guidance and control systems and subsystems applied to navigation systems for aircraft, spacecraft, and missiles [AGARD LS 60] p0236 N74 14345

Introductory remarks Test technology trends applied to performance tests of inertial guidance systems p0236 N74 14346

PIGA Acceleration tests on vertical 10G 3 hertz table centrifuge and vibration tests of inertial guidance systems p0236 N74 14347

Inertial guidance system centrifuge testing development and characteristics of test equipment p0236 N74 14348

Laboratory evaluation of electro optically aided space navigation systems demonstration of design concept and hardware performance p0236 N74 14350

Aircraft inertial system testing and evaluation in the United Kingdom p0237 N74 14352

Aircraft navigation systems testing with a high precision reference development of Completely Integrated Reference Instrumentation System (CIRIS) p0237 N74 14353

Inertial guidance system sea testing p0237 N74 14354

### STAGNATION POINT

Distortion of and generated turbulence in stagnation region of two dimensional body p0180 N72 20307

### STANDARDIZATION

Standardization of test procedures for determining stress corrosion cracking in high strength alloys and steels under various environments conference p0285 N72 21900

Standardization of test methods for stress corrosion in metals p0285 N72 21902

Standardization of tests and classification of color perception abnormalities in military personnel p0077 N73 15071

### STANDARDS

Factors standards and techniques involved in testing protective headgear p0104 N72 19183

Application of linear elastic fracture mechanics to developing stress corrosion cracking test standards [NASA TM X 68303] p0286 N72 21905

### STAR TRACKERS

Development of Canopus star sensor for stabilization of X4 technology satellite p0192 N72 19499

### STARTING

Starting conditions of mixed compression axisymmetric hypersonic inlet p0267 N72 16715

### STATISTICAL ANALYSIS

Formulas for calculating depolarization effects on dipole radiation in statistically homogeneous and isotropic dielectric constant medium p0119 N71 23460

Statistical study of physiological and psychological factors in grounding of Italian Air Force flight crews p0095 N72 14091

Statistical estimating techniques for inversion of radiative transfer equation in determining atmospheric temperature from microwave radiation measurements p0125 N72 16113

Exponential probability distribution analysis for extrapolating aerospace system performance statistics from test results p0281 N73 23903

Measurement of atmospheric attenuation at the frequencies of 15 19 and 34 GHz atmospheric effects on microwave transmission p0149 N74 13870

### STATISTICAL CORRELATION

Statistical forecast of signal attenuation with tropospheric scatter using meteorological parameters p0120 N71 23471

### STATISTICAL DISTRIBUTIONS

Pattern of accident distribution for V-STOL aircraft in United States of America p0029 N71 23426

Analysis of deterministic and random flight data p0195 N73 10455

### STATISTICAL WEATHER FORECASTING

Analysis of 11 GHz band propagation in Portugal for rain accumulation prediction p0148 N74 13689

### STEADY FLOW

Numerical method for evaluating discontinuous downwash distribution for steady flow over swept and rectangular wings p0010 N71 29349

### STEADY STATE

Inlet steady state and dynamic performance tests with F 111A and YF 12 aircraft [NASA TM X 67495] p0266 N72 16709

### STEELS

Tensile strength measurements on steel wire reinforced aluminum alloys p0208 N72 12501

Materials and designs of protective armor p0102 N72 19143

Microelectrodes for measuring pH gradients during stress corrosion of aluminum alloys and 1020 steel exposed to potassium chloride p0286 N72 21909

Microstructure and stress corrosion behavior of welded steel joints p0286 N72 21910

Microscopic characteristics of stress corrosion cracking in steel with high yield strength p0289 N72 21925

Influence of thermomechanical treatment on stress corrosion cracking in steel p0289 N72 21930

### STIFFENING

Analysis of dynamics of stiffened plates using finite element modelling of flat and curved stiffened panels p0293 N73 29911

### STRAIN RATE

Accelerated slow strain rate tensile method p0288 N72 21924

Strain rate experiments to evaluate resistance to stress corrosion cracking p0289 N72 21927

### STRAPDOWN INERTIAL GUIDANCE

Proceedings of conference on inertial navigation components and systems with emphasis on concepts and techniques involving cost and performance tradeoffs [AGARD CP 116] p0227 N73 20684

Numerical analysis of effects of various parameters affecting accuracy and stability of strapdown inertial navigation systems p0227 N73 20685

Development of single degree of freedom gyroscope for application in strapdown inertial guidance system p0228 N73 20688

Dynamically tuned gyro in strapdown systems p0229 N73 20697

Development of electrostatic gyro system p0229 N73 20698

Inertial grade instrumentation for precision strapdown reference system p0149 N73 20699

### STRAPS

Negative g strap for restraint and performance during aircraft acrobatics vibration and crash impact p0104 N72 19158

**STRATIFICATION**

Angular deviations of radio waves from horizontal stratification p0128 N72 21139

**STRATOSPHERE**

Nitrogen oxides nuclear weapon testing corollary and stratospheric ozone p0217 N74 14275  
Effect of supersonic transport upon the ozone layer studied in a two dimensional photochemical model with transport p0218 N74 14278  
Chemical kinetic in the stratosphere atmospheric composition and atmospheric chemistry based on photolysis reaction reactions p0218 N74 14279  
Measure of minor constituents in the stratosphere by Concord 001 p0219 N74 14288

**STRATOSPHERE RADIATION**

Reaction of ozone with nitrogen oxides at high altitudes p0217 N74 14274

**STRESS (PHYSIOLOGY)**

Stresses and adaptation problems associated with large scale long range rapid reaction time aerial troop deployments p0069 N71 20360  
Physiological responses to interacting stresses of exercise and hypercapnia under acute and chronic exposure to ambient P sub CO2 of 21 mm Hg p0070 N71 20370  
Physical exercise effects on stress tolerances of trained and untrained subjects p0091 N71 22306  
Analysis of spatial disorientation reports by flying personnel during 14 year period [NASA CR 126786] p0071 N72 25032  
Combined stress effects in human communication and motion sickness biodynamics p0104 N73 19144  
Temperature and noise irradiation effects on human energetic metabolism during vigilance task p0106 N73 19155  
Reaction assessment of vestibular disorientation stress for aircrew selection using visual displays and tasks p0079 N73 21096  
Hashish smoking effects on human oxygen consumption during physical stress and safe diving ability p0081 N73 21115

**STRESS (PSYCHOLOGY)**

Stresses and adaptation problems associated with large scale long range rapid reaction time aerial troop deployments p0069 N71 20360  
Combined stress effects in human communication and motion sickness biodynamics p0104 N73 19144  
Characteristics of life stress in a population of military aviators p0088 N74 18787  
In flight psychic load in student pilots evaluated by means of Vanil Mandel's Acid (VMA) changes in urinary excretion p0089 N74 18790

**STRESS ANALYSIS**

Heat transfer and thermal stress calculations for gas turbine rotor blade design p0261 N71 17401  
Thermal stress and low cycle fatigue reliability analyses on high temperature structural machine materials p0261 N71 17403  
Stressing systems and environmental methods used by European Federation stress corrosion tests p0285 N72 21904  
Smooth beam and pre-cracked specimen testing of stress behavior of aluminum alloys p0288 N72 21920  
Analysis of aircraft structural loads in operational flight to determine effects of pilot performance and aircraft characteristics [AGARD R 608] p0055 N73 27895  
Analysis of effect of damping on response of structure to acoustic excitation and experimental method for determining damping coefficients p0293 N73 29917  
Analysis of programs for acoustic testing of composite material components and development of theory for predicting natural frequencies mode shapes and stresses in composite panels p0293 N73 29918  
Development of rational analytic theory for analyzing fatigue of airframes based on maximum stress field parameter and maximum load excursion rate p0295 N73 29931  
Development of procedure for estimating fatigue life of airframes to eliminate errors caused by neglecting effect of stress redistribution after localized yielding p0295 N73 29933  
Analysis of errors in fatigue life prediction procedures and methods for improving accuracy of prediction analysis techniques p0295 N73 29934  
Acoustic fatigue design data part 3 design criteria for aircraft structural elements to reduce effects of acoustic stress [AGARDOGRAPH 162 PT 3] p0293 N74 19550

**STRESS CORROSION**

Standardization of test procedures for determining stress corrosion cracking in high strength alloys and steels under various environments conference [AGARD CP 96] p0295 N72 21900  
Stress corrosion cracking in aircraft structures and various materials historical review p0285 N72 21901  
Standardization of test methods for stress corrosion in metals p0285 N72 21902  
Stress corrosion tests of 2XXX series high strength aluminum alloy in laboratory environment p0285 N72 21903  
Stressing systems and environmental methods used by European Federation stress corrosion tests p0285 N72 21904

Application of linear elastic fracture mechanics to developing stress corrosion cracking test standards [NASA TM X 68303] p0286 N72 21905

Determination of stress corrosion cracking parameter for 300M steel p0286 N72 21906  
Effects of repassivation and crack velocity on stress corrosion cracking in alloys p0286 N72 21907  
Stress corrosion index for measuring conjoint action between stress and corrosion in stress corrosion of Al alloys p0286 N72 21908  
Microelectrodes for measuring pH gradients during stress corrosion of aluminum alloys and 1020 steel exposed to potassium chloride p0286 N72 21909  
Microstructure and stress corrosion behavior of welded steel joints p0286 N72 21910  
Cantilever bending tests for determining susceptibility of high strength alloys to stress corrosion cracking p0287 N72 21911

Stress corrosion tests of titanium alloys and electron beam welded titanium alloys p0287 N72 21912  
Threshold stress intensity values and crack propagation rates for stress corrosion of high strength steels in aqueous environment p0287 N72 21913  
Laboratory equipment for testing stress corrosion of brittle loaded WOL specimens and monitoring crack growth p0287 N72 21914  
Krafts model for determining susceptibility of Zn Mg Cu aluminum alloys to stress corrosion crack growth p0287 N72 21915  
Pre-cracked cantilever beam and long term beam exposure tests for determining stress corrosion of Al alloys in sea water p0288 N72 21919

Stress corrosion in two aluminum alloys p0288 N72 21921  
Stress corrosion behavior of the forgings made from Al Zn Mg Cu alloys p0288 N72 21922  
Effects of heat treatment size specimen type and test environment on two point load on hardened stainless steels during stress corrosion cracking tests p0288 N72 21923  
Microscopic characteristics of stress corrosion cracking in steel with high yield strength p0289 N72 21925  
Hot salt stress corrosion cracking of titanium alloys used as advance heat shields in space shuttles [NASA TM X 68304] p0289 N72 21926

Strain rate experiments to evaluate resistance to stress corrosion cracking p0289 N72 21927  
Techniques for studying crack morphology contaminants and electrochemistry in stress corrosion p0289 N72 21928

Influence of thermomechanical treatment on stress corrosion cracking in steel p0289 N72 21930  
Mechanical properties and stress corrosion of hot rolled alloy plates p0289 N72 21931  
Summary of conference on stress corrosion testing methods [AGARD AR 52] p0292 N73 18931

**STRESS CYCLES**

Survey and analysis of literature on fatigue damage accumulation in aircraft materials and structures [AGARD AG 157] p0290 N72 22918

**STRESS MEASUREMENT**

Error sources in elastic stress measurements on fiber reinforced composite materials p0207 N72 12498  
Stress corrosion index for measuring conjoint action between stress and corrosion in stress corrosion of Al alloys p0286 N72 21908  
Measures to determine psychophysiological reactions of military flight crews to flying stress p0105 N73 19148

**STRESS RELAXATION**

Role of isothermal stresses generated during oxidation and modes of stress relaxation p0202 N73 23605

**STRESS STRAIN DIAGRAMS**

Axial tension tests for stress strain response of matrix and reinforcing fibers in glass epoxy resin composites p0207 N72 12500  
Stress strain fatigue mechanisms of beryllium reinforced aluminum composites having rough or smooth surfaces p0208 N72 12504

**STRESS STRAIN TIME RELATIONS**

Thermal stress and low cycle fatigue reliability analyses on high temperature structural machine materials p0261 N71 17403  
Electrical conductance measurements for determining stress strain time life of glass fiber to resin interlaminar bond in reinforced plastic materials exposed to water p0258 N72 12505

**STRESSES**

Stress effects of temperature and altitude on human performance p0069 N71 20363  
Models for determining failure modes and stress limits of spacecraft parts p0190 N71 36782

**STRUCTURAL ANALYSIS**

Assessment of structural design philosophy in combining computerized structural analysis with mathematical programming p0283 N71 20130  
Analysis of acoustic fatigue life of structures subjected to jet noise and application to design of aircraft structures Part I [AGARD AG 162 PT 1] p0290 N72 29893  
Proceedings of conference on acoustic fatigue to show effects of aerodynamic loads response of structures structural design and fatigue test methods [AGARD CP 113] p0297 N73 29905

Analysis of dynamics of stiffened plates using finite element modeling of flat and curved stiffened panels p0293 N73 29911

Analysis of response and fatigue characteristics of an alloy integrally machined planks with emphasis on acoustic fatigue properties p0293 N73 29912

Analysis of structural response to acoustic loading and preparation of data sheets for various conditions of acoustic loads p0293 N73 29914

Structural response and endurance tests of aircraft structural components to determine effect of critical environment on acoustic fatigue p0294 N73 29920

Acoustic fatigue tests of aluminum alloy structural elements under narrow band random loading with zero mean stress in skin p0294 N73 29921

Development of fatigue life prediction procedures based on measured stress time histories and mathematical model for description of random vibrations p0294 N73 29926

Application of high strength structural materials for aerospace vehicles and use of fracture control procedures for improved damage tolerance p0294 N73 29928

Application of growth rate data and analytical integration mode for predicting crack growth under variable amplitude loading p0295 N73 29932

Development of procedure for estimating fatigue life of airframes to eliminate errors caused by neglecting effect of stress redistribution after localized yielding p0295 N73 29933

The design of compatible structures p0297 N74 15606

Application of a design analysis system to a space shuttle preliminary design p0298 N74 15613

**STRUCTURAL DESIGN**

Heat transfer prediction for turbine blade design p0257 N71 17374

Efficiency of air cooling blade design for Olympus 593 gas turbine engine p0257 N71 17376

Boundary layer optimization for small turbine blade design with cusped trailing edge p0258 N71 17380

Heat transfer and thermal stress calculations for gas turbine rotor blade design p0261 N71 17401

Mathematical programming techniques applied to aerospace structural design algorithmic tools applications and literature review [AGARD AG 149 71] p0283 N71 20128

Basic concepts of mathematical programming applied to structural design of aerospace vehicles p0283 N71 20129

Design optimization of aerospace structures made of elastic perfectly plastic materials p0283 N71 20131

Mathematical programming applications to structural design optimization literature review p0283 N71 20132

Computer programs for optimum least weight design of complex elastic aerospace structures p0284 N71 20136

Optimum structural design and reliability analysis p0284 N71 20138

Flying safety factors in close to ground operational design of XH 51 helicopter p0300 N71 23430

Comparison of performance predictions and flight data for optimizing transonic wind tunnel design p0014 N72 11871

Transonic wind tunnel design for model testing at high Reynolds number p0016 N72 1887

Optimality criteria in structural design with application to sandwich structures solid sections and three dimensional bodies p0034 N72 15958

Design and aerodynamic performance of diamond target thrust reverser p0284 N72 18695

Biodynamics of sports injuries applied to sports equipment design p0094 N72 19128

Second Symposium on Structural Optimization [AGARD CP 123] p0295 N74 15596

Survey of the state of the art of optimization technology within NATO countries p0296 N74 15598

Application of optimality criteria approaches to automated design of large practical structures p0296 N74 15599

Recent developments in the Case optimization program using mathematical programming approach p0296 N74 15600

Structural design applications of geometric programming p0296 N74 15601

The optimization of statically indeterminate structures by means of approximate geometric programming p0296 N74 15602

Application of discrete function technique to random search in nonlinear constrained structural optimization problems p0296 N74 15603

Integer programming algorithms for optimum structural design p0296 N74 15604

Shape optimization using mathematical programming and model techniques p0297 N74 15605

The design of compatible structures p0297 N74 15606

Optimization of stiffened panels p0297 N74 15607

Optimal joint positions for space trusses p0297 N74 15608

Application of a general method for flutter optimization p0297 N74 15609

Minimum weight design of surface effect vehicles using the sieve search technique p0297 N74 15610

Automated sizing of large structures by mixed optimization methods p0297 N74 15611

Optimization of aircraft structures with multiple stiffness requirements p0297 N74 15612

- Optimization and design of the rear fuselage of the A 300 B aircraft structure p0298 N74 15614  
The double iteration method in structural optimization p0298 N74 15615  
Homologous deformation of stiffened shells for radio telescope structures p0298 N74 15618  
Optimization of the layout of trusses combining strategies based on Michell's theorem and on the biological principles of evolution p0298 N74 15617
- STRUCTURAL DESIGN CRITERIA**  
Development of aerodynamic structural design data to reduce effects of acoustic fatigue on flat and singly curved sandwich panels - Part 2 p0290 N73 14898  
[AGARD AG 162 PT-2] p0290 N73 14898  
Analysis of structural response to acoustic loading and preparation of data sheets for various conditions of acoustic loads p0293 N73 29914  
On turbulence environment and design criteria - application of power spectral techniques for analyzing gust loads at low altitudes p0059 N74 17734  
Design problems of military aircraft as affected by turbulence - analytical prediction of pilot task proficiency under vibration environment p0059 N74 17735  
Structural loads and gust criteria - comparison of gust load analysis methods for application to aircraft design p0059 N74 17739
- STRUCTURAL ENGINEERING**  
Structural data on brittle nonmetallic materials for use in designing military vehicles p0205 N71 200:7  
[AGARD AG 152 71] p0205 N71 200:7  
Second Symposium on Structural Optimization [AGARD CP 123] p0295 N74 15311  
Necessary and sufficient conditions for global structural optimality p0295 N74 15597
- STRUCTURAL FAILURE**  
Models for determining failure modes and stress limits of spacecraft equipment p019 N71 30782  
Structural and mechanical characteristics of human connective tissue p0101 N72 19140  
Stress corrosion cracking: aircraft structures and various materials - historical review p0185 N72 21901  
Nondestructive test for failure inspection and quality control of composite structures and materials - conference [AGARD R 590] p0290 N72 24934  
Address on problems of acoustic fatigue p0292 N73 29906  
Techniques for controlling time to fatigue crack initiation in design of aircraft structures and application of residual stress analyses p0295 N73 29930  
Development of rational analytic theory for analyzing fatigue of airframes based on maximum stress field parameter and maximum load excursion ratio p0295 N73 29931  
Application of growth rate data and analytical relation models for predicting crack growth under variable amplitude loading p0295 N73 29932  
Analysis of errors in fatigue life prediction procedures and methods for improving accuracy of prediction analysis techniques p0295 N73 29934
- STRUCTURAL MEMBERS**  
Analysis of programs for acoustic testing of composite material components and development of theory for predicting natural frequencies, mode shapes, and stresses in composite panels p0293 N73 29918
- STRUCTURAL RELIABILITY**  
Structural crashworthiness performance of conventional automobiles and performance of structural devices designed for protection p0101 N72 19142
- STRUCTURAL STABILITY**  
Application of composite materials for structural purposes to show limitations and failure characteristics p0211 N73 27481  
Application of high strength structural materials for aerospace vehicles and use of fracture control procedures for improved damage tolerance p0294 N73 29928  
Development of rational analytic theory for analyzing fatigue of airframes based on maximum stress field parameter and maximum load excursion ratio p0295 N73 29931  
Development of procedure for estimating fatigue life of airframes to eliminate errors caused by neglecting effect of stress redistribution after localized yielding p0295 N73 29933
- STRUCTURAL STRAIN**  
Effect of environment and stress cycling on in-service structural failure of airframes and procedures for predicting safe operational conditions p0295 N73 29929
- STRUCTURAL VIBRATION**  
Structural vibrations in aerospace operations and effects on man p0076 N73 17099
- STRUCTURAL WEIGHT**  
Components for low weight small volume aircraft gas turbine engines p0262 N71 26455
- SUBCRITICAL FLOW**  
Approximation of pressure distribution on wing body configurations at subcritical speeds p0003 N71 19164
- SUBMERGING**  
Effects of positive tyrol acceleration on blood oxygen saturation and on heart pressure at high depth breathing air and low fluid densities in white body water immersion experiment [NASA CR 117199] p0058 N71 20358
- SUBSONIC AIRCRAFT**  
Wind tunnel evaluation of interference drag in turbofan engine-wing configuration of subsonic aircraft p0004 N71 19378  
Computerized prediction of flow field interference forces and moments on aircraft stores at subsonic speeds p0006 N71-19385
- SUBSONIC FLOW**  
Numerical analysis of aerodynamic loads on wing and tail surfaces with oscillations in unsteady supersonic and subsonic flow including interference lift [AGARD CP-8C 71-PT-1] p0007 N71 29333  
Aerodynamic load predicting for control surfaces in unsteady supersonic and subsonic flow p0007 N71 29334  
Numerical analysis of aerodynamic loads and coefficients for tandem and T tail surfaces harmonically oscillating in subsonic flow p0007 N71 29335  
Computer programs for evaluating subsonic flow over wing tail wings with folded tips, T tails, and cruciform tail surfaces p0009 N71 29341  
Computer programs for calculating airforce coefficients of wing horizontal tail and fin horizontal tail oscillating in subsonic flow p0009 N71 29342  
Application of lifting surface theory to wing with control surfaces in unsteady subsonic flow p0009 N71 29347  
Time dependent technique applied to subsonic and transonic flow nozzle solutions p0268 N72 16712  
Velocity distribution measurement of subsonic axisymmetric inlet for compressor matching p0287 N72 16714  
Numerical analysis of inviscid gas flow due to accelerating cylinder and computation of steady subsonic flow p0181 N72 27302
- SUBSONIC FLUTTER**  
Developments in unsteady aerodynamics of helicopter rotary wings to analyze stall flutter, transient effects of interactions and wake induced instabilities p0017 N73 14001
- SUBSONIC SPEED**  
Pressure plotting tests on swept wings for analyzing scale effect at high subsonic speeds p0015 N72 11867  
Aerodynamic configurations of swept wings to improve lift performance at stall in higher range of subsonic speeds p0047 N73 15010  
Numerical analysis of minimum time climbing procedure and minimum fuel - burning procedure for typical subsonic aircraft p0053 N72 24052  
A survey of drag prediction techniques applicable to subsonic and transonic aircraft design p0019 N74 14711
- SUBSONIC WIND TUNNELS**  
Analysis of problems involved in operation of large wind tunnels at subsonic and supersonic speeds p0172 N73 26239  
Influence of free stream turbulence on turbulent boundary layer in relation to wind tunnel testing at subsonic speeds p0184 N73 26283
- SUBSTRATES**  
Effects of substrates on stability of superconductor and electrical properties of superconductors for various conditions p0063 N73 19031
- SULFIDES**  
Multicomponent diffusion theory as applied to oxidation corrosion and sulfation of complex heat resistant alloys p0202 N73 23609
- SULFUR**  
Sulfur sodium and chloride contaminants in gas turbines p0202 N73 23610
- SUMMARIES**  
Small tactical missiles for 1980 and beyond - Volume I - Executive summary [AGARD AR 57 VOL 1] p0307 N74 73504
- SUNSPOTS**  
A numerical model of TEC over Europe for sunspot minimum conditions p0187 N74 14085
- SUPERCONDUCTING MAGNETS**  
Application of superconducting magnetics for plasma physics experiments and as component for future thermonuclear reactors p0063 N73 19033  
Analysis of effect of mass on operation of airborne superconductor magnetic system with aluminum stabilized conductor p0063 N73 19034  
Characteristics of large lightweight saddle coil superconducting pole magnet for airborne magnetohydrodynamic generators p0064 N73 19038  
Characteristics of superconducting electric generators to show effect of electromechanical, electromagnetic, and cryogenic parameters on design p0064 N73 19039  
Features and characteristics of superconducting electrical machines and design of synchronous electric generator for airborne use p0064 N73 19040
- SUPERCONDUCTIVITY**  
Proceedings of conference on application of superconductivity technology to auxiliary power systems for aircraft and missiles [AGARD CP 104] p0063 N73 19030
- SUPERCONDUCTORS**  
Effects of substrates on stability of superconductor and electrical properties of superconductors for various conditions p0063 N73 19033  
Analysis of a rotating current loss mechanism in superconductors with comparison of performance of rotatable configurations p0063 N73 19032  
Development of electromagnetic fields using superconductors with high current densities and application to power conversion and energy storage p0063 N73 19035

- Characteristics of conventional alternators and aircraft electrical power systems and comparison with electric systems using superconductors p0064 N73 19036  
Development of superconducting homopolar machines with multiple discs and superconducting field winding using liquid metals for armature sliding contacts p0064 N73 19037  
Utilization of superconductors to store and discharge electric energy p0064 N73 19041  
Application of superconducting coils for energy storage and determination of optimizing parameters for inductive energy storage p0064 N73 19042  
Effects of electromagnetic forces energy radiation, and discharge losses on design of superconducting coils for energy storage elements p0064 N73 19043
- SUPERCritical FLOW**  
Development of procedures for determining planar inviscid supercritical flow over airfoils [AGARD AG 156] p0018 N72 22001
- SUPERCritical WINGS**  
Aerodynamic Drag [AGARD CP 124] p0018 N74 14709  
Drag of supercritical airfoils in transonic flow comparison with conventional airfoil drag coefficients p0020 N74 14719
- SUPRHHIGH FREQUENCIES**  
Development of multi beam antenna system and combiner switch for producing variable coverage radiation pattern for satellite communication system p0193 N72 19507  
Generation of superhigh frequency power using negative impedance characteristics of avalanche diodes in reflection amplifiers p0194 N72 19511  
Amplitude fading of superhigh frequency geostationary communications satellite signals considering atmospheric refraction p0142 N73 26139
- SUPERPOSITION (MATHEMATICS)**  
Computer program for determining low speed interference effects of flow fields about arbitrary bodies by superposition p0005 N71 19377
- SUPERSONIC AIRCRAFT**  
Flight and wind tunnel evaluations of flow field effects on performance of supersonic underwing exhaust nozzle at transonic speeds p0003 N71 19386  
[NASA TM X 66887] p0003 N71 19386  
Wind tunnel surveys of flow fields about wing fuselage store configuration inlets of transonic and supersonic aircraft [NASA TM X 66885] p0004 N71 19371  
Aerodynamic flow field interference effects on supersonic inlets p0004 N71 19372  
Possible high energy fuels for supersonic aircraft p0251 N72 11670  
Kerosene type fuel for supersonic and hypersonic aircraft p0251 N72 11671  
Synthetic high temperature lubricants thickened by complex esters for supersonic aircraft p0255 N72 11701  
Design problems of inlets and nozzles used in supersonic and V-STOL propulsion systems p0267 N72 21819  
[NASA TM X 67741] p0267 N72 21819  
Active dosimetry for protection and control of cosmic rays in supersonic aircraft p0275 N72 26047  
Wind tunnel models for determining heat interference and performance of inlet airframe combination in supersonic aircraft design p0037 N72 27019  
Comparison of flying quality criteria documents for United Kingdom and US aircraft to show areas of inadequacy in assessing acceptability of aircraft p0038 N72 26019  
Analysis of criteria for evaluation of high performance aircraft and results obtained on aircraft equipped with control augmentation systems p0039 N72 32025  
Intrasonic detection of propagating atmospheric shock waves caused by supersonic aircraft p0138 N73 14161  
Effect of engine failure on aerodynamic characteristics of supersonic aircraft p0045 N73 17003  
Application of active controls to suppression of flutter for supersonic aircraft p0045 N73 17005  
Artificial stabilization to correct control deficiencies for high performance aircraft p0045 N73 17009  
Development of electrical generation and distribution systems for supersonic aircraft using solid state switching and remote control of protective devices p0068 N73 19054
- SUPersonic BOUNDARY LAYERS**  
Numerical techniques for determining flow characteristics of supersonic turbulent boundary layer in adverse pressure gradient p0179 N72 20390
- SUPersonic COMMERCIAL AIR TRANSPORT**  
Development of criteria specification for supersonic transport aircraft and application to safe handling qualities for all regimes of flight operations p0039 N72 32027
- SUPersonic DRAG**  
Aerodynamic resistance characteristics of airframe propulsion systems of transport and military aircraft [AGARD CP 71 71] p0001 N71 19353  
Swept wing body configurations for reduced drag at supersonic speed p0002 N71 19358  
Aerodynamic configuration effects of propulsion system integration into supersonic transport design p0004 N71 19373
- SUPersonic FLIGHT**  
Biophysical hazards of cosmic radiation during SST and manned space flight p0075 N71 26046  
Effects of thrust characteristics on longitudinal stability in supersonic flight p0044 N72 16937



## SUBJECT INDEX

## SUBJECT INDEX

Operational performance and transmission system  
on worldwide Defense Communications System  
network p0133 N73 10208

Feasibility of all digital implementation of worldwide  
analog communications systems p0133 N73 10209

Kalman filtering algorithm for detecting continuous wave  
interference signals in digital telecommunications  
p0133 N73 10210

Intermodulation interference effects of metal surface  
transmitters and receivers in near-field location trans-  
mission system p0134 N73 10212

Conference on atmospheric attenuation and rainfall  
effects on ultrahigh frequency telecommunication systems  
[AGARD CP 107] p0140 N73 26121

Design engineering for radio communication systems  
considering troposphere transmission characteristics  
p0141 N73 26128

Criteria for planning ultrahigh frequency telecommu-  
nication system considering radioelectrical and meteorological  
measurements p0141 N73 26129

Horizontal radio link system for measuring ultrahigh  
frequency absorption from diu to rain p0141 N73 26130

Use of differential phase and gain for predicting perfor-  
mance of ultrahigh frequency telecommunication system  
p0141 N73 26132

Effects of rain and atmospheric turbulence on ultrahigh  
frequency space communication radio link p0143 N73 26143

Propagation effects of frequency sharing  
[AGARD CP 127] p0145 N74 13846

Introductory survey to session 1: Propagation over  
irregular terrain telecommunication transmission loss  
prediction p0145 N74 13847

**TELEMETRY**

Development and operation of programmable PCM  
telemetry encoder for data storage and processing during  
space missions p0193 N72 19504

Facilities and techniques for measuring antenna radia-  
tion patterns of spacecraft telemetry and telecommand anten-  
nas p0144 N72 19512

Introductory survey to session 4: Propagation data for  
interference probability determination p0147 N74 13861

**TELEOPERATORS**

Computerized teleoperator applications to manned  
aerospace systems p0281 N73 23904

**TELEPHONY**

Automatic equalizers of telephone channels for fast  
transmission of digital data p0122 N73 16093

**TELEVISION CAMERAS**

Image processing and pattern recognition system for true  
variant images using TV cameras as terrain computer  
p0154 N72 11196

**TELEVISION EQUIPMENT**

Characteristics of satellite television recording system  
using continuous line scanning with constantly open  
aperture p0192 N72 19498

**TELEVISION RECEPTION**

Characteristics of satellite television recording system  
using continuous line scanning with constantly open  
aperture p0192 N72 19498

**TELEVISION TRANSMISSION**

Advanced digital video transmission systems for  
television transmission and video storage p0148 N72 22172

**TELLURIC LINES**

Variable coefficient propagation of diffusion for  
analyzing inhomogeneous media through inhomogeneous  
penetration of spectra p0125 N72 16318

**TEMPERATURE**

Stress effects of temperature and altitude on human  
performance p0093 N71 20363

**TEMPERATURE DISTRIBUTION**

Temperature, turbulence and spectral distributions for  
temperature and velocity in turbulent boundary layer  
p0175 N72 70276

**TEMPERATURE EFFECTS**

Temperature distribution effects on mechanical  
behavior of silicon dioxide composite materials  
p0297 N72 12499

**TEMPERATURE MEASUREMENT**

Catalytic surface effects on the thermopile combustion  
gas temperature measurements in engines  
p0257 N71 17379

Error correction procedures for gas engine infrared sea  
surface temperature measurements p0124 N72 16105

Error sources in sea surface temperature measurements  
by satellite borne scanning radiometer  
p0124 N72 16107

Analysis of requirements, instruments and procedures  
for measurement of aircraft temperatures up to Mach 2.3  
and altitudes up to 80,000 feet p0196 N73 20493

Turbulent and free heat transfer in short duration  
and rapidly varying flows p0199 N73 20945

**TEMPERATURE MEASURING INSTRUMENTS**

Heat transfer and heat flux measuring sensors for gas  
turbine engines p0257 N71 17377

Development and characteristics of high intensity diode  
reading heat flux gauge of gas state type  
p0190 N71 36781

**TENSILE STRENGTH**

Tensile strength measurements in steel wire reinforced  
aluminum alloys p0208 N72 12401

## TENSILE STRESS

Accelerated slow strain rate tensile method  
p0288 N72 21924

## TENSORS

Equations for time mean values of incompressible  
turbulent flow and eddy viscosity dependence on second  
invariant of deformation tensor p0176 N72 20280

## TERMINAL BALLISTICS

Theoretical analysis of fuel ignition by hot projectile and  
ignition delay time as function of temperature and width  
of hot gas region p0252 N72 11683

## TERMINAL FACILITIES

Satellite communication terminal for ships  
p0133 N73 10204

Analysis of terminal air traffic control procedures to  
determine impact of automation on air traffic controller  
personnel p0233 N73 23700

Numerical analysis of optimal control and sequencing  
of air traffic control operations in near terminal area  
p0233 N73 23701

Analysis of development program for improving US air  
traffic control procedures for 1980 time period  
p0235 N73 23718

Wake Vortex Avoidance System program (WVAS):  
design and implementation of model based monitoring and  
predictive system for safety from wake vortices  
p0058 N74 17732

## TERMINAL GUIDANCE

Characteristics of electro optical terminal guidance  
systems, area correlators, and gated trackers used for  
guidance and control of tactical missiles p0227 N72 27688

Terminal guidance techniques for midcourse guidance and  
terminal guidance systems with application to control and  
guidance of tactical standoff missiles p0227 N72 27691

Characteristics of command to line of sight guidance and  
semi active homing missile systems applied to guidance  
and control of tactical missiles p0227 N72 27692

Application of microwave guidance sensors for tracking  
and fire control systems used in missile attack on small  
tactical targets p0227 N72 27693

Terminal guidance system testing based on nondet-  
ectable tests and evaluation by simulated live targets to increase  
test cost effectiveness p0237 N74 14356

## TERRAIN

Universal system for assigning colors to terrain  
[AGARD AG 159] p0187 N72 25346

Effect of terrain screening on the differential mechanisms  
of propagation p0146 N74 13850

## TERRAIN ANALYSIS

Radar imagery for producing cumulative frequency curves  
of terrain slopes in geographic mapping p0122 N72 16091

Interpretation of side looking airborne radar imagery for  
vegetation mapping  
[NASA CR 125451] p0122 N72 16092

Multispectral reflectivity curves in near infrared and visible  
regions for planning remote multiband terrain photogra-  
phy p0124 N72 16109

Aerial multispectral color photography for remote  
recognition of soils and rocks p0124 N72 16110

Introductory survey to session 1: Propagation over  
irregular terrain telecommunication transmission loss  
prediction p0145 N74 13847

The propagation of electromagnetic waves over irregu-  
lar terrain: radio wave diffraction and the simulation loss  
p0146 N74 13848

The radiative diagram of a antenna used in terrestrial  
microwave line of sight system: radiation patterns of  
parabolic antennas in terrestrial relay system  
p0147 N74 13859

## TERRAIN FOLLOWING AIRCRAFT

Terrain avoidance radar for US Army rotary wing  
aircraft p0032 N72 11922

## TEST CHAMBERS

Problems of wind tunnel design and testing  
[AGARD R 600] p0173 N74 16987

## TEST EQUIPMENT

Effectiveness of reliability programs for avionics equip-  
ment p0189 N71 36773

Cost effectiveness of built-in test provisions in aircraft  
operations p0189 N71 36780

Proceedings of conference on applications of laser  
technology for aerodynamic measurements  
[AGARD LS 49] p0199 N72 25493

Mathematical models and numerical analysis of coherent  
optical systems used as holographic calibration system  
p0199 N72 25496

Principles for producing holograms and methods of  
calibrating reference patterns between reference and test  
reference light waves p0199 N72 25493

Development and characteristics of holographic cameras  
for use with light sensitive detectors  
[NASA CR 126761] p0199 N72 25501

A new analytical technique for continuous NO detect in  
the range from 0.1 to 5000 PPM p0219 N74 14278

Testing of theory and methods of quantize a discrete  
systems and subsystems applied to navigation systems  
for aircraft space flight and missiles p0216 N74 14345

Aviation flight systems testing with a high precision  
reference standard system for integrated navigation  
[Reference Implementation System (RIS)] p0237 N74 14353

## TESTS

### TEST FACILITIES

Biodynamics, acceleration, time acceleration stresses,  
human tolerances centrifuges test facilities and associated  
biography p0094 N71 23337

Equipment and facilities for biodynamic research in US  
and Canada p0095 N71 23342

Equipment and facilities for biodynamic research in NATO  
European countries p0095 N71 23343

Development and conduct of national and international  
programs to determine variations in creep test techniques  
and establishment of standard creep test procedures  
[AGARD R 581 71] p0285 N71 25449

Inventory of acoustic fatigue test facilities in NATO  
countries p0172 N71 34253

[AGARD R 584 71] p0172 N71 34253

Conference on theoretical methods and wind tunnel  
facilities for transonic aerodynamic testing of aircraft at  
high Reynolds numbers p0011 N72 11854

[AGARD CP 83 71] p0011 N72 11854

Minimum level of Reynolds number for reliable flow  
simulation in transonic test facilities  
[NASA TM X 67412] p0012 N72 11859

High Reynolds number aerodynamic ground testing by  
moving test specimens or rocket sleds p0016 N72 11885

Flow phenomena and test facilities for transonic so-  
unds p0172 N72 12162

[AGARD AR 37 71] p0172 N72 12162

History of aircraft crash injury studies and facilities for  
simulation p0103 N72 19150

Indoor testing for vehicle impact p0103 N72 19154

Stress corrosion tests of 7XXX series high strength  
aluminum alloys in laboratory environment p0285 N72 21903

Developments in aerodynamic test facilities to show past  
experience present status, free flight techniques and future  
plans [AGARD R 603] p0122 N73 18250

Low cycle fatigue testing at high temperatures  
[AGARD R 604] p0292 N73 18916

Analysis of factors involved in design of wind tunnel  
for testing V-STOL aircraft models p0018 N73 22956

Analysis of problems involved in operation of large wind  
tunnels at subsonic and supersonic speeds p0172 N73 26239

Analysis of minimum run times required for differential  
measurements at transonic speeds during wind tunnel  
tests p0173 N73 18243

Development of method for determining response of box  
type structures subjected to high intensity acoustic load-  
ing p0293 N73 29915

Pollution control of airport engine test facilities  
p0219 N74 14285

Testing philosophy and methods of guidance and control  
systems and subsystems applied to navigation systems  
for aircraft, spacecrafts and missiles p0236 N74 14345

[AGARD LS 60] p0236 N74 14345

Introductory remarks: Test technology trends applied  
to performance tests of inertial guidance systems  
p0215 N74 14346

PIGA: Acceleration tests of vertical 100 g 3 Hz table  
centrifuge and vibration tests of inertial guidance  
systems p0236 N74 14347

Inertial guidance system centrifuge testing develop-  
ment and characteristics of test equipment p0235 N74 14348

Testing of an attitude control and for spinning rockets  
p0236 N74 14349

Laboratory evaluation of electronic output of inertial  
navigation systems: development of design concept  
and hardware performance p0236 N74 14350

Trends towards standardized software and hardware for  
test systems based on process computer with interface  
unit and input/output peripheral p0236 N74 14351

Inertial guidance system sled testing p0237 N74 14354

Role of simulations in the study and development of  
the CROTAL system ground to air close defense  
weapon system p0237 N74 14355

Problems of wind tunnel design and testing  
[AGARD R 600] p0173 N74 16987

Progress toward large European transonic Ludwig Tube  
wind tunnel p0174 N74 16989

The development of an efficient and economical system  
for the generation of great transonic flows suitable for model  
testing at high Reynolds numbers p0174 N74 16990

Facilities for aerodynamic testing at hypersonic speeds  
p0174 N74 16993

Inventory of research activities in aerodynamic  
[AGARD R 609] p0304 N74 17664

**TEST FIRING**

Terminal guidance system testing based on nondet-  
ectable tests and evaluation by simulated live targets to in-  
crease test cost effectiveness p0237 N74 14356

**TEST PILOTS**

Development and application of pilot workload monitor-  
ing performance and handling intensity of flight  
p0219 N72 32028

**TEST VEHICLES**

Aviation flight systems testing with a high precision  
reference standard system for integrated navigation  
[Reference Implementation System (RIS)] p0237 N74 14353

**TESTS**

Effects of total ionizing radiation on test programs  
p0190 N71 36781

## TF 30 ENGINE

Inlet random pressure fluctuation effects on turbine engine stall characteristics p0037 N72 27022

## THERMAL CONTROL COATINGS

Thermal control coatings for refractory gas turbine materials p0259 N71 17391  
Performance of aluminate coatings in simulated high temperature tests on gas turbine engine inlets [NASA CR 116374] p0259 N71 17393

## THERMAL ENVIRONMENTS

Heat tolerance of athletes during muscular exercise in various thermal environments p0070 N71 20366

## THERMAL EXPANSION

Dilatometric thermal expansion measurements on high temperature structural materials p0293 N71 21358  
Thermal expansion behavior of platinum, Al<sub>2</sub>O<sub>3</sub>, tungsten alloys and graphite [AGARD AR 38] p0299 N72 24960

## THERMAL FATIGUE

Thermal fatigue behavior of fiber reinforced metal alloy gas turbine blades p0259 N71 17390  
Thermal stress and low cycle fatigue reliability analyses on high temperature structural machine materials p0261 N71 17403

## THERMAL PROTECTION

Hot salt stress corrosion cracking of titanium alloys used as radiative heat shields in space shuttles [NASA TM X 68304] p0289 N72 21926

## THERMAL RESISTANCE

Computerized optimization of thermal resistant gas turbine blades p0260 N71 17400

## THERMAL STABILITY

Assessment of high temperature stability of synthetic lubricants for aircraft gas turbines p0254 N72 11695  
Thermal stability of trimethyl propane ester based lubricating oil for aircraft engines p0254 N72 11699  
Thermodynamic stability diagrams of high temperature O<sub>2</sub> - carbon reactions p0201 N73 23602

## THERMAL STRESS

Combined environmental stress effects on human performance p0169 N71 20362

## THERMAL STRESSES

Heat transfer and thermal stress calculations for gas turbine rotor blade design p0261 N71 17401  
Role of isothermal stresses generated during oxidation and modes of stress relaxation p0202 N73 23605

## THERMOCLINES

Influence of solar energy absorption and air water interactions on seasonal thermocline of sea p0241 N73 23623

## THERMOCOUPLES

Catalytic sulfide effects on thermocouple combustion gas temperature measurement in jet engines p0247 N71 17379

## THERMODYNAMIC CYCLES

Thermodynamic cycle and power output parameters of gas turbine p0262 N71 17394

## THERMODYNAMIC PROPERTIES

Thermodynamic properties of small gas turbines for power generation in aeronautics, space and industry p0262 N71 17395  
Inter design and the thermodynamic cycle of turbine engine at supersonic speeds with normal shock p0267 N72 16317

Techniques for measuring elastic, viscoelastic, ultimate strength, thermal and electrical properties of fiber reinforced composites p0209 N72 25939

Development of method for analyzing performance of magnetohydrodynamic generator based on thermodynamic properties and flow characteristics p0265 N73 19551

Analysis of heat transfer properties and thermal stability of materials used for aircraft and spacecraft construction [AGARD R 606] p0100 N73 25958

## THERMONUCLEAR POWER GENERATION

Application of superconducting magnetics for plasma physics experiments and as confinement for future thermonuclear reactors p0063 N73 19033

## THERMOPHYSICAL PROPERTIES

Analysis of heat transfer properties and thermophysical properties of materials used for aircraft and spacecraft construction [AGARD R 306] p0100 N73 25958

## THERMOPHONES

Design and performance of thermophone loud coated high efficiency temperature axial flow turbine p0260 N71 17399

## THICKNESS

Antibond remote catalytic converter deposit coating in automobiles p0173 N72 16399

## THIN WINGS

Calculated values of aerodynamic coefficients for thin wings obtained by linearized potential flow [AGARD R 593 71] p0101 N71 35198

## THREE DIMENSIONAL BOUNDARY LAYER

Partial differential equations for calculating three dimensional incompressible turbulent boundary layers p0127 N72 20285

## THREE DIMENSIONAL FLOW

Three dimensional flow testing of high lift flow models p0266 N72 16312  
Three dimensional flow model for analysis of swept wing structure and dynamics p0114 N71 21411

Improved mixing length model applied to three dimensional boundary layer assuming turbulent shear stress in same direction as laminar p0177 N72 20284

Numerical analysis of three dimensional ideal gas flow and Euler equations of motion p0182 N72 27307

Application of functional analysis to obtain exact semi-analytical solutions of boundary layer flows under turbulent and laminar conditions p0041 N73 15003

The drag resulting from three dimensional separations caused by boundary layer diverters and nacelles in subsonic and supersonic flow p0021 N74 14728

Survey of computational methods for three dimensional supersonic inviscid flows with shocks p0185 N74 22919

## THROATS

Procedure for predicting performance characteristics of second throat diffusers in ejector systems p0183 N73 17250

## THRUST

Engine aircraft interference thrust inlets, nozzles, and propulsion systems conference [AGARD CP 91 71] p0263 N72 16685

Wind tunnel tests of afterburner thrust and core flow for models with simplified hollow nacelles p0263 N72 16689

Full scale thrust performance tests of prototype dual stream propelling nozzle p0263 N72 16691

Thrust measurement integration for V-STOL models and transit performance of lift fan configurations p0264 N72 16693

Determination of thrust and drag characteristics for integrated aircraft engine lift fan configuration p0038 N72 2701

Effects of thrust characteristics on longitudinal stability in supersonic flight p0043 N73 16997

## THRUST AUGMENTATION

Augmented flap wing distribution augmentation nozzle and noise reduction for jet STOL aircraft [NASA CR 125540] p0264 N72 16698

Rapid mixing nozzles, thrust vector control and thrust augmentation for V-STOL aircraft p0265 N72 16699

## THRUST MEASUREMENT

Presentation of helicopter level flight performance as power coefficient compared with tip speed of advance ratio for range of thrust coefficients p0047 N73 21014

## THRUST REVERSAL

Design and aerodynamic performance of ramjet target thrust reversal p0264 N72 16695

## THRUST VECTOR CONTROL

Advantages of thrust vectoring in manned air combat maneuver p0264 N72 16694

Rapid mixing nozzles, thrust vector control and thrust augmentation for V-STOL aircraft p0265 N72 16699

## THUNDERSTORMS

Ionospheric oscillations caused by infrasonic waves propagating from thunderstorms p0136 N73 14148

Thunderstorm cloud height and fading statistics for ATIS 5 ultrahigh frequency signal transmission to earth p0142 N73 26141

## TILTING ROTORS

Review of tilting rotor technology and comparison of tilting rotor performance with standard rotary wings p0048 N73 21027

Wind tunnel tests to determine effects of blade twist and aerobically on tilt rotor performance from hover to mach number 0.7 p0051 N73 21049

Aerodynamic dynamic and aeroelastic problems in rotary wing design for helicopters and V-STOL aircraft with application to hingeless rotor systems p0051 N73 21051

## TIME DEPENDENCE

Time dependent technique applied to subsonic and transonic flow nozzle solutions p0266 N72 16312

Nonlinear time dependent problems in fluid dynamics p0185 N74 22916

## TIMING DEVICES

Economic analysis of integrated time frequency systems for aircraft p0235 N73 23717

## TIP DRIVEN ROTORS

Development of rotary wings with cold, hot, and mixed cycle tip jet propulsion systems and application for torque free rotor drive system p0048 N73 21026

## TIP SPEED

Presentation of helicopter level flight performance as power coefficient compared with tip speed of advance ratio for range of thrust coefficients p0047 N73 21014

## TISSUES (BIOLOGY)

Relative biological effects of heavy gamma rays on living tissue p0075 N72 26049

## TITANIUM ALLOYS

Properties and selective applications of titanium alloys in aircraft and jet engines p0206 N71 27045

Stress corrosion tests of titanium alloys in deaerated, welded titanium alloys p0287 N72 21912

Hot salt stress corrosion cracking of titanium alloys used as radiative heat shields in space shuttles [NASA TM X 69304] p0289 N72 21925

Failure of welded joints in Ti-Al-Sn alloy type alloys in CO<sub>2</sub> vapor p0289 N72 21929

Design factors and microstructural parameters and optimum design to operate at high temperature p0213 N71 27499

## TOOTH DISEASES

Consequences of flight effects on tooth health and decay in military pilots p0072 N71 22309

## TORPEDOES

Three axis gyro stabilized torpedo platform p0270 N73 20702

## TORQUERS

Angular momentum exchange systems, jet expulsion systems, and magnetic torquers for active satellite attitude control p0277 N72 12866

## TOXICITY

Ophthalmological examination of animal and drug effects on performance of navigation personnel p0082 N73 21122

## TOXICITY AND SAFETY HAZARD

Effects of chemical fire extinguishing agents containing bromotrifluoromethane on cardiovascular and nervous systems of dogs, monkeys, and beavers [AGARD R 593] p0077 N73 17106

## TOXICOLOGY

Environmental toxicological impact of aircraft operations p0222 N74 14306

## TRAILING EDGES

Boundary layer optimization for small turbine blade design with cusped trailing edge p0258 N71 17380

Transonic wind tunnel determination of blunt trailing edge effects on drag and lift characteristics of wing profile p0012 N72 11862

New investigations for reducing the base drag of wings with a blunt trailing edge effects of splitter plates and splitter wedges on aerodynamic drag coefficients p0020 N74 14723

## TRAINING SIMULATORS

Evaluation of the role of the simulator in training airborne ASW operations p0107 N74 18801

## TRAJECTORY OPTIMIZATION

Computerized multistage decision process for radar operator and collision avoidance trajectory control p0279 N73 23886

Development of computer program for determining minimum time trajectory and comparison with gradient method of computation p0053 N73 24053

## TRANQUILIZERS

Residual effects of hypnotic drugs on human nervous function and performance p0080 N73 21106

Post performance under certain hypnotic tranquilizers and barbiturate type drugs p0080 N73 21110

Spectral analysis of human rhythmic performance to evaluate tranquilizer effects p0081 N73 21116

Flight safety factors in prescribing tranquilizing drugs for flying personnel p0082 N73 21123

Comparison of motor and direct effects on human mental and psychomotor functions p0082 N73 21126

Computer electrocystography in evaluating the influence of psychopharmacological drugs on vigilance p0100 N74 20742

## TRANSEQUATORIAL PROPAGATION

Electron and space activities in the G-mere wave propagation and electron density research p0038 N74 21612

## TRANSFER FUNCTIONS

Transfer functions in modeling human psychodynamic structural analysis responses [AGARD R 580 71] p0009 N71 23276

Computation and measurements of dynamic aircraft transfer functions to atmospheric turbulence p0007 N71 23213

Human factors for defining transfer functions in pilot modeling p0007 N71 23214

Measurement of light attack jet various angles using point spread function and modulation transfer function techniques p0242 N73 23629

## TRANSFORMATIONS (MATHEMATICS)

Transformation functions for turbulent boundary layers with optimal pressure gradient p0176 N72 20278

## TRANSVERSE RADIO PROPAGATION

Tropospheric scatter propagation and prediction of radio transmission characteristics [AGARD CP 71] p0117 N71 23457

Boundary layer theory and meteorological parameters to radar range prediction over sea surface p0121 N71 23474

Water evaporation interference in phase measurements by transverse microwave propagation over sea surface p0140 N73 26125

Scattering in transverse ultrasonic frequency range due to rain p0141 N73 26133

During properties of elevated layers p0147 N74 13867

The occurrence of very high field strengths at ground level during propagation over sea in the frequency range 60-5000 MHz p0147 N74 13863

Interference measurements at 15.7 GHz over a long transmission path - tropospheric scatter p0148 N74 13864

Statistics of high level jet - tropospheric scatter at 2.4 GHz and 2.6 GHz and its comparison with the statistics of the ground wave structure - radio interference and tropospheric scatter p0148 N74 13866

## TRANSISTORS

Characteristics of solid state power amplifiers for direct amplification using diodes and triodes and application to interplanetary space probes p0194 N72 19510

Linear transistor models in network analysis - Adaptive behavior measurements and analysis by computer p0166 N74 13976

## TRANSITION FLOW

Flow measurement and interpretation for V-STOL models and transition performance of lift fan configurations p0264 N72 16699

# SUBJECT INDEX

## TRANSMISSION EFFICIENCY

Near infrared measurements on erbium laser transmission in carbon dioxide atmosphere p0124 N72 18108

## TRANSMISSION LOSS

Transmission loss in tropospheric transhorizon propagation on 12 GHz scatter link p0118 N71 23458

Path loss prediction methods for tropospheric radio scatter propagation links and comparison with performance tests p0120 N71 23469

Mathematical prediction model for tropospheric radio transmission loss over rough surfaces p0120 N71 23472

Statistical model for tropospheric radio propagation loss in rough surface path between transportable mobile antennas p0120 N71 23473

The propagation of electromagnetic waves over irregular terrain radio wave diffraction and transmission loss p0148 N74 13848

Variations in diffraction loss due to tropospheric effects at frequencies between 180 MHz and 10 GHz in hilly terrain p0148 N74 13852

Estimating attenuation, scintillation and scattering due to rainfall for satellite ground systems p0147 N74 13856

Interference measurements at 15.7 GHz over a long transhorizon path tropospheric radio scattering mechanisms p0148 N74 13864

Troposcatter propagation in an equatorial climate p0148 N74 13865

Estimation of very low field strength levels on line of sight paths over sea due to meteorological conditions p0148 N74 13868

Synthesis of passive filters with infinite attenuation ports realized with weak noise components applied to high degree Cauer filters p0167 N74 13923

## TRANSMITTER RECEIVERS

Intermodulation interference effects of metal surface transmitters and receivers in near field locations of transmission system p0134 N73 10212

## TRANSONIC FLOW

Scale effects in flows past swept wings at transonic speeds p0011 N72 11855

Reynolds number effects in viscous mixed interactions on transonic swept wings p0011 N72 11856

Method for estimating transonic buffet boundary and Reynolds number effects for straight and swept wings p0011 N72 11857

Flow model for shock induced leading edge transonic flow turbulence and reattachment in low speed stall of airfoil p0011 N72 11858

Mathematical model of Reynolds number for transonic flow simulation in transonic test facilities p0012 N72 11859

Transonic wind tunnel tests of effectiveness of high lift devices on swept and straight wings in controlling flow separation p0012 N72 11860

Transonic wind tunnel determination of Reynolds number effect on jet flap deflected drag divergence, pressure distribution and buffet onset p0012 N72 11861

Transonic wind tunnel determination of flap trailing edge effects on drag and lift characteristics of wing profile p0012 N72 11862

Reynolds number effect on flow past body of revolution at transonic speed p0012 N72 11864

Transonic performance of double flow engine nacelle at intake and afterbody at high Reynolds numbers p0013 N72 11866

Measurement accuracy and flow simulation for transonic testing in wind tunnels p0014 N72 11872

Equivalent body of revolution for slender high Reynolds number effect on transonic flow past two dimensional airfoil p0014 N72 11874

Sound field generation by transonic flow over perforated surface liners in wind tunnels p0014 N72 11876

Hydraulic equipment for high Reynolds number testing in transonic wind tunnel p0015 N72 11880

Computation of transonic mixed flow with unbounded shock waves p0192 N72 27306

Analytical approach for loss and deflection behavior of cascades in transonic flow including axial mixing flow variation p0268 N73 19870

Vaporization thermodynamics of C203 protective scales under transonic flow conditions p0202 N73 23617

On the prediction of aerodynamic loads on oscillating wings in transonic flow p0273 N74 18651

A survey of computational methods for 2D and 3D transonic flows with shocks p0185 N74 27320

## TRANSONIC FLUTTER

Compendium of NASA Langley report on transonic steady aerodynamics flutter calculations p0113 N74 18152

## TRANSONIC NOZZLES

Time dependent flow applied to subsonic and transonic flow nozzle solutions p0266 N72 16712

## TRANSONIC SPEED

Wind tunnel tests at transonic speeds of Reynolds number effects on force and pressure coefficients for the slender wing at transonic speed p0012 N72 11861

Free flight models for transonic testing at high Reynolds numbers p0015 N72 11880

Flow characteristics and test facilities for transonic speeds p0172 N72 12452

Flight tests to determine buffet characteristics of four high performance aircraft during transonic maneuvers p0043 N73 15017

Analysis of minimum run times required for stationary measurements at transonic speeds during wind tunnel tests p0173 N73 26243

A survey of drag prediction techniques applicable to subsonic and transonic aircraft design p0019 N74 14711

## TRANSONIC WIND TUNNELS

Consideration by NATO of transonic wind tunnel requirements to support evolution of aeronautical and aerospace systems during next decade p0175 N71 25073

AGARD report on engine airplane interference and wall correction in transonic wind tunnel tests p0010 N71 36400

Conclusions and recommendations concerning wind tunnel tests of interaction between engine flow and wall corrections in transonic wind tunnels p0010 N71 36401

Completion of responses to questionnaire on engine airplane interference in transonic tests p0011 N71 36402

Wall corrections for airplanes with interference in transonic wind tunnel tests p0011 N71 36403

Conference on theoretical methods and wind tunnel facilities for transonic aerodynamic testing of aircraft at high Reynolds numbers p0011 N72 11854

Transonic wind tunnel testing for predicting flight performance characteristics of aircraft p0013 N72 11865

Comparison of performance predictions and flight data for optimizing transonic wind tunnel design p0014 N72 11871

Measurement accuracy and flow simulation for transonic testing in wind tunnels p0014 N72 11872

Transonic wind tunnel testing requirements for simulating transonic aerodynamic data at high Reynolds numbers p0014 N72 11873

Sound field generation by transonic flow over perforated surface liners in wind tunnels p0014 N72 11876

Methods for solving engine airplane interference and wall corrections in transonic wind tunnel tests for predicting aerodynamic performance of airplane design p0014 N72 11877

Hydraulic equipment for high Reynolds number testing in transonic wind tunnel p0015 N72 11880

Comparison between conventional blowdown and Ludwieg tube driven transonic wind tunnels for high Reynolds number range p0015 N72 11881

Performance and operating characteristics of high Reynolds number blowdown and Ludwieg tube driven transonic wind tunnel testing p0016 N72 11884

Transonic wind tunnel design for model testing at high Reynolds number p0016 N72 11887

Aerodynamic testing at high Reynolds numbers and transonic speeds in NATO p0016 N72 12978

Data and recommendations for transonic tests of models p0263 N72 16687

Analysis of problems involved in operation of large wind tunnels at subsonic and supersonic speeds p0172 N73 26239

Development of numerical methods for predicting wall corrections in transonic wind tunnels with vorticity effects p0173 N73 26241

Fluid motion problems in design and operation of flow speed in transonic wind tunnels p0181 N73 26279

Present and future need for high Reynolds number transonic wind tunnels in testing analysis of design vehicles in an improved manner p0181 N73 26282

Effects of turbulence and shock waves on aerodynamic measurements at transonic speeds p0184 N73 26284

Design of vented walls for transonic wind tunnels with analysis of parameters affecting noise generation p0184 N71 26285

Problems of wind tunnel design and testing p0173 N74 16987

Project status of stage European transonic tunnel type wind tunnel p0174 N74 16989

The development of an efficient and economical system for the generation of transonic flows suitable for model testing at high Reynolds number p0124 N74 16990

Hydraulic design of wind tunnel p0174 N74 16992

## TRANSPORT AIRCRAFT

Flight applications of transport aircraft design p0026 N71 20068

Flight testing of transport aircraft for handling and performance in NATO applications p0026 N71 20069

Adaptive variability of flow field for wind tunnel testing of transport aircraft in design of Reynolds number and Mach number effects in Mach number p0015 N72 11879

Advanced flight test methods for transonic flow field measurements p0013 N72 11876

Analysis of the problem of transonic flow field measurements in wind tunnels p0010 N71 36400

Criteria for design of transonic flow field measurements in wind tunnels p0010 N71 36401

Design of transonic flow field measurements in wind tunnels p0010 N71 36402

# TROPOSPHERIC SCATTERING

Development and characteristics of dual cargo hook system for use on military transport helicopters p0048 N73 21022

Numerical methods for determining range and radius of action performance of transport and combat aircraft and effects of various parameters on performance p0052 N73 24043

Aerodynamic coefficients for calculating transport aircraft performance using wind tunnel and scale models p0053 N73 24046

Analysis of parameters affecting choice of engines for transport and combat aircraft during design process p0053 N73 24048

Development of two methods for optimizing design of subsonic swept wing jet transport aircraft p0054 N73 24054

Analysis of aerodynamic characteristics affecting selection of short takeoff transport aircraft p0055 N73 27012

Analysis of research and development programs involving construction of short takeoff transport aircraft in Germany p0055 N73 27013

Aerodynamic characteristics of high lift wing concepts for application to commercial short takeoff transport aircraft p0292 N73 29908

The problem of installing a modern high bypass engine on a twin jet transport aircraft p0021 N74 14727

Theoretical horizontal tail loads and associated aircraft responses of an autopilot controlled jet transport flying in turbulence analysis of problem areas associated with rigid aircraft controlled by simple autopilot p0059 N74 17742

## TRANSPORT PROPERTIES

Transport properties of oxide scales formed on oxidant resistant alloys p0201 N73 23604

## TRAVELING IONOSPHERIC DISTURBANCES

Asymptotic methods for determining propagation angles of internal gravity waves traveling at ionospheric heights p0136 N73 14144

Traveling ionospheric disturbance generation by tropospheric stream p0136 N73 14147

Gravity wave effects on current time changes of daily traveling ionospheric disturbances p0136 N73 14155

Solar radio interferometry for traveling ionospheric disturbance detection p0138 N73 14158

Computerized simulation of gravity wave perturbed traveling ionospheric disturbances using ray tracing p0139 N73 14163

Ray tracing computations of high frequency signal propagation in disturbed traveling ionospheric disturbances p0139 N73 14165

Accuracy of gravity wave effects on traveling ionospheric disturbances following linear response p0139 N73 14166

Effects of traveling ionospheric disturbances following nonlinear response on high frequency band propagation p0139 N73 14167

## TREADMILLS

Retraining aircraft with abnormal exercise tests and normal ordinary programs to flying status p0085 N74 13788

## TROPOSPHERE

Ultra-high resolution radar for sensing real time index structure of troposphere p0123 N72 16121

Radiowave radar detection and photography of gravity waves in troposphere p0137 N73 14152

## TROPOSPHERIC SCATTERING

Tropospheric scattering of radio waves effects on radio signals wave propagation and radio signal transmission p0014 N72 11874

Transonic wind tunnel tests of effectiveness of high lift devices on swept and straight wings in controlling flow separation p0012 N72 11860

Transonic wind tunnel determination of Reynolds number effect on jet flap deflected drag divergence, pressure distribution and buffet onset p0012 N72 11861

Transonic wind tunnel determination of flap trailing edge effects on drag and lift characteristics of wing profile p0012 N72 11862

Reynolds number effect on flow past body of revolution at transonic speed p0012 N72 11864

Transonic performance of double flow engine nacelle at intake and afterbody at high Reynolds numbers p0013 N72 11866

Measurement accuracy and flow simulation for transonic testing in wind tunnels p0014 N72 11872

Equivalent body of revolution for slender high Reynolds number effect on transonic flow past two dimensional airfoil p0014 N72 11874

Sound field generation by transonic flow over perforated surface liners in wind tunnels p0014 N72 11876

Hydraulic equipment for high Reynolds number testing in transonic wind tunnel p0015 N72 11880

Computation of transonic mixed flow with unbounded shock waves p0192 N72 27306

Analytical approach for loss and deflection behavior of cascades in transonic flow including axial mixing flow variation p0268 N73 19870

Vaporization thermodynamics of C203 protective scales under transonic flow conditions p0202 N73 23617

On the prediction of aerodynamic loads on oscillating wings in transonic flow p0273 N74 18651



## TROPOSPHERIC WAVES

- Meteorological effects on tropospheric propagation of radio waves p0120 N71 23470
- Amplitude fading of superhigh frequency geostationary communications satellite signals considering atmospheric refraction p0142 N73 26139
- Slant path attenuation of ultrahigh frequency signals from sun tracking radiometers p0142 N73 26140
- Variations in diffraction loss due to tropospheric effects at frequencies between 180 MHz and 10 GHz in hilly terrain p0148 N74 13852
- Tropospheric influence on the screening effect due to a mountain ridge on 3 GHz radio transmission loss due to atmospheric refraction p0148 N74 13853
- Introductory survey to session 4. Propagation data for interference probability Determinations p0147 N74 13861
- Interference measurements at 15.7 GHz over a long transmission path tropospheric radio scattering mechanisms p0148 N74 13864
- Troposcatter propagation in an equatorial climate p0148 N74 13865
- Statistics of high level beyond horizon signals at 2.2 GHz and 2.8 GHz and measurements of the variation of the signal edge structure - radio interference and tropospheric scatter p0148 N74 13866

## TROPOSPHERIC WAVES

- Improved tropospheric wave propagation for military applications p0114 N71 21410

## TRUSSES

- Optimal joint positions for space trusses p0297 N74 15608
- Optimization of the layout of trusses combining strategies based on Michell's theorem and on the biological principles of evolution p0298 N74 15617

## TUNGSTEN

- Thermal expansion behavior of platinum-A12O3 tungsten alloys and graphites p0299 N72 24960

## TURBINE BLADES

- Advanced cooling systems and heat resistant materials for turbine blades of high temperature aeronautical gas turbine engines p0257 N71 17372
- Heat transfer prediction for turbine blade design p0257 N71 17374
- Mathematical model for calculating blade temperatures in convective cooled gas turbines p0257 N71 17375
- Efficiency of an cooling blade design for Olympus 593 gas turbine engine p0257 N71 17376
- Heat transfer and exchange measurements on fixed turbine blades in high temperature combustion chamber p0257 N71 17378
- Boundary layer optimization for small turbine blade design with cusped trailing edge p0258 N71 17380
- Aerodynamic and thermodynamic performance of small cooled gas turbine engine blades p0258 N71 17382
- Transpiration cooled blades for high temperature inlet in gas turbine engines p0258 N71 17384
- Performance prediction for turbine blade film cooling with injection through hole p0259 N71 17388
- Thermal fatigue behavior of fiber-reinforced nickel alloy gas turbine blades p0259 N71 17390
- Fabrication of cobalt alloy and nickel alloy gas turbine blades and discs p0259 N71 17392
- Film cooling of gas turbine blades by an injection through holes p0260 N71 17394
- Heat transfer in liquid metal cooled gas turbine blades p0260 N71 17398
- Computerized optimization of thermal resistant gas turbine blades p0260 N71 17400
- Technological aspects of film cooling for blades in high temperature gas turbines p0261 N71 17404
- Conference on high temperature turbines detailing effects of film cooling on blade profile loss p0261 N71 22699
- Corrosion resistant materials for nozzle guide vanes and turbine blades subject to vanadium containing fuel combustion p0263 N73 23613
- Production of lamellar and fibrous composite materials from directional solidification of eutectic alloys and application to gas turbine blades and vanes p0212 N73 27492
- Directional solidification of eutectic alloys and application to turbine blades and gas turbine engine components p0213 N73 27494

## TURBINE ENGINE

- Reduction of harmful emissions of turbine engine exhaust system p0251 N72 11675
- Post crash fire safety of helicopter turbine engine fuels p0253 N72 11688
- Refining metal alloys with protective coatings for use in structural components of turbine engines p0270 N73 23514
- Application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers p0111 N73 21630
- Gas sampling and analysis in combustion phenomena [AGARDGRAPH 1684H] p0111 N74 22799

## TURBINES

- Synthesis of properties of phosphate ester for turbine lubrication p0274 N72 11696
- High speed tribological film of polluting flow in gas turbine turbine cascade p0271 N73 19918

## TURBOCOMPRESSORS

- Influence of axial velocity density ratio on compressor cascade performance in compressible flow p0269 N73 19805
- Mathematical model for prediction of axial compressor performance including effect of annulus wall boundary layers p0270 N73 19812
- Shock wave boundary layer interaction in compressor cascades p0271 N73 19816

## TURBOFAN ENGINES

- High bypass turbofan powered propulsion simulator for airframe engine integration analyses at subsonic and supersonic speeds p0003 N71 19389
- Wind tunnel evaluation of interference drag in turbofan engine wing configuration of subsonic aircraft p0004 N71 19378
- Optimizing propulsive lift system for turbofan STOL aircraft considering cost effectiveness p0026 N71 20063
- Destabilizing factors affecting supersonic inlets and turbofan engines of propulsion system p0066 N72 16711
- Analysis of intake duct noise of turbofan engine and effect on duct structure due to acoustic fatigue p0293 N73 29916
- Detailed exhaust emission measurements of three different turbofan engine designs p0217 N74 14276

## TURBOGENERATORS

- High entrance temperatures for improved performance of turbogenerators and gas turbine engines p0257 N71 17373

## TURBOJET ENGINES

- Reduction of NO formations by premixing p0217 N74 14272
- Theoretical study of the residual evolution of polluting products in turbojet exhausts p0220 N74 14294
- Modelization of turbomachine combustors for pollution studies p0220 N74 14298

## TURBOMACHINE BLADES

- Universal curves which relate general properties of two dimensional boundary layers on turbomachine blades p0268 N73 19795
- Predictions of boundary layer transition on turbomachine blades p0268 N73 19797
- Optimization method for turbomachine blade design based on boundary layer concepts p0299 N73 19801
- Role of boundary layers in axial flow turbomachines and prediction of the effects p0269 N73 19806
- Calculation method for external heat transfer to turbine blades p0269 N73 19807
- Boundary layer behavior in supersonic straight and annular blade cascades of fixed and mobile types p0271 N73 19817

## TURBOMACHINERY

- Effectiveness of turbine cooling systems for high temperature inlets p0258 N71 17385
- [NASA TM X 86702] p0258 N71 17385
- Boundary layer effects in turbomachines p0268 N73 19794
- [AGARD AG 184] p0268 N73 19794
- Method for calculating three dimensional turbulent boundary layer separation applied to simple turbomachine case p0270 N73 19808
- Methods of testing rotating components of turbomachines compared with tests on complete turbines p0271 N73 26800
- [AGARD AG 187] p0271 N73 26800
- Application of boron aluminum composite material for construction of turbine blades with low notch sensitivity in high cycle fatigue p0213 N73 27497

## TURBOPROP ENGINES

- Exhaust emission measurements on the GE 164 7 turboprop engine p0212 N74 14286

## TURBULENCE

- Optical properties of pure and turbulent sea water p0241 N73 33624
- Digital techniques in turbulence research p0184 N74 18924
- [AGARDGRAPH 174] p0184 N74 18924
- Numerical treatment of fluid dynamical stability problems p0185 N74 22921

## TURBULENCE EFFECTS

- Tropospheric turbulence effects on superhigh frequency transmissions at low elevation angles p0115 N71 21422
- Measurement of human operator performance in single axis tracking task during simulated turbulent conditions p0040 N72 32014
- Influence of degree of turbulence on aerodynamic coefficients of cascade p0268 N73 19798
- Effect of free stream turbulence level on turbulent boundary layer behavior p0268 N73 19799
- Turbulent flow stream turbulence on turbulent boundary layer interaction with wind tunnel exit p0184 N73 26281
- Effects of turbulence and imposed wind tunnel mean flow on transfer speeds p0184 N73 26284
- Aircraft response to turbulence - new model systems, methods using power spectral density methods - factors affecting operational efficiency of time to take off and climb p0058 N74 17729
- The effects of wind speed and shear on aircraft approach and landing - a comparison of flight test and flight control system for short takeoff aircraft p0058 N74 17730
- The effects of wind speed and shear on aircraft approach and landing - a comparison of flight test and flight control system for short takeoff aircraft p0058 N74 17731
- On turbulence environment and design criteria application of power spectral techniques for analyzing gust loads at low altitudes p0059 N74 17734
- Design problems of military aircraft as affected by turbulence - analytical prediction of pilot task proficiency under vibration environment p0059 N74 17735
- Influence of turbulence on helicopter design and operation - analysis of structural loads, pilot workload and passenger comfort effect on atmospheric turbulence p0059 N74 17736
- Data requirements on turbulence in the earth's atmosphere shear layer for STOL design criteria - development of low altitude gust model for determining importance of gust parameters on STOL aircraft performance p0059 N74 17737
- Experience with a low altitude turbulence model for autoland certification - correlation of gust model data with statistical analysis of flight test results p0059 N74 17738
- Structural loads and gust criteria - comparison of gust load analysis methods for application to aircraft design p0059 N74 17739
- Rational calculation of design gust loads in relation to present and proposed airworthiness requirements - effects of atmospheric turbulence on aerodynamic configuration of short haul aircraft p0059 N74 17740
- CAS design for good handling in turbulence - development of design criteria for stability augmentation systems for alleviation of gust effects p0059 N74 17741
- Theoretical horizontal tail loads and associated aircraft responses of an autopilot controlled jet transport flying in turbulence - analysis of problem areas associated with rigid aircraft controlled by simple autopilot p0059 N74 17742
- The design of automatic flight control systems to reduce the effects of atmospheric disturbances - flight tests of experimental automatic pilots on BAC 111 aircraft p0060 N74 17743
- Application of energy management concepts to flight path control in turbulence - strategy for control of approach and flight path with emphasis on landing approach p0060 N74 17744
- A new approach to gust alleviation of a flexible aircraft using an open loop device - application to control system of SE 310 aircraft p0060 N74 17745

## TURBULENCE BOUNDARY LAYER

- Interference flow field of thin plate configuration in supersonic turbulent boundary layer channel p0003 N71 19365
- Turbulent boundary layers - jets and wakes - conference p0175 N72 20273
- [AGARD CP 93] p0175 N72 20273
- Experimental studies of flow distribution near wall in turbulent boundary layer p0175 N72 20275
- Temperature fluctuations and spectral distributions for temperature and velocity in turbulent boundary layer p0175 N72 20276
- Bursts and streamwise momentum deficits in wall region and turbulent boundary layer p0175 N72 20277
- Transformation function for turbulent boundary layers with optional pressure gradient p0176 N72 20278
- Approximation of two dimensional turbulent boundary layer under arbitrary wall and free flow conditions p0176 N72 20279
- Coupling effects between wall heating and axial pressure gradients in turbulent boundary layer flow p0176 N72 20281
- [NASA CR 125903] p0176 N72 20281
- Model for compressible turbulent boundary layer applicable to flows with pressure gradient and surface mass transfer p0176 N72 20283
- Partial differential equations for calculating three dimensional incompressible turbulent boundary layers p0177 N72 20285
- Convective turbulent boundary layer velocity and temperature profiles with zero pressure gradient p0177 N72 20287
- Turbulent boundary layer measurements on large thermally insulated flat plate at Mach numbers 2.5 to 4.5 p0177 N72 20288
- Streamwise pressure gradient effects on two dimensional compressible turbulent boundary layers at high Reynolds number p0177 N72 20289
- Application of transport equation for Reynolds shear stress to calculating two dimensional flow in turbulent boundary layers p0179 N72 20298
- Effects of adverse pressure gradient on compressible turbulent boundary layer flow p0179 N72 20299
- Numerical calculation of laminar-turbulent transition in supersonic turbulent boundary layer in adverse pressure gradient p0179 N72 20300
- Heat transfer and pressure distribution on flat plate and pressure profiles for turbulent boundary layers at subsonic and supersonic speeds p0179 N72 20301
- Low speed wind tunnel measurements of turbulent boundary layer flow at high Reynolds number p0180 N72 20302
- Mathematical models for calculating turbulent boundary layer spectra with gusts p0180 N72 20303
- Effect of adverse pressure gradient on turbulent boundary layer spectra with gusts p0180 N72 20304
- Effect of adverse pressure gradient on turbulent boundary layer spectra with gusts p0180 N72 20305

# SUBJECT INDEX

## V STOL AIRCRAFT

Universal curves which relate general properties of two dimensional boundary layers on turbomachine blades p0268 N73 19795  
Effect of free stream turbulence level on turbulent boundary layer behavior p0268 N73 19799  
Optimization method for turbomachine blade design based on boundary layer concepts p0259 N73 19801  
Method for calculating three dimensional turbulent boundary layer separation applied to simple turbomachine case p0270 N73 19308  
Method for prediction of turbulent boundary layer flow in vaneless radial diffuser and experimental validation p0270 N73 19809  
Interaction of shock wave with turbulent boundary layer at moderate supersonic Mach numbers p0271 N73 19815  
Influence of free stream turbulence on turbulent boundary layer in relation to wind tunnel testing at subsonic speeds p0184 N73 26283  
Effect of surface pressure fluctuations on response of panels underlying attached and separated turbulent boundary layers and shock waves p0292 N73 29910  
Measurements of the drag of some characteristic aircraft cross sections immersed in turbulent boundary layers p0019 N74 14714  
Numerical treatment of boundary layer problems. Finite difference solutions p0185 N74 22918

## TURBULENT FLOW

Complex turbulent flows as perturbations of classical thin shear layers and application of Prandtl approximation p0175 N72 20274  
Equations for time mean values of incompressible turbulent flow and eddy viscosity dependence on second invariant of deformation tensor p0176 N72 20280  
Existence of velocity potential for viscous fluid flow and role of compressibility in turbulent subsonic and supersonic flow p0176 N72 20282  
Turbulent shear flow model for asymmetric free jet two dimensional free shear layer and flat plate boundary layer [NASA CR 125904] p0177 N72 20286  
Flow visualization techniques and hot wire anemometer data for shear flow turbulence p0178 N72 20290  
Fluctuating properties in turbulent flow due to convection of diffusion production dissipation and pressure transport p0178 N72 20297  
Hot wire measurement of curved two dimensional shear turbulent jet p0178 N72 20294  
Stabilization of turbulent shear layer flow in rotating systems by convoluted forces p0180 N72 20305  
Distortion of grid generated turbulence in stagnation region of two dimensional body p0180 N72 20307  
Controlling free stream turbulence of passive devices [AGARD R 596] p0182 N72 20367  
Phys. at structure of turbulent shear flows in interacting gas flow p0182 N73 17262  
Application of functional analysis to obtain exact semi-empirical solution of boundary layer flows under turbulent initial and boundary conditions p0041 N73 15003  
Finite difference procedure for computing behavior of two dimensional boundary layers and transition model to predict location and extent of transition region p0268 N73 19796  
Analysis of aerodynamic noise produced by rotating wings and methods for noise reduction based on slender airfoils and blade tip modifications p0252 N73 21053  
Effects of stream line curvature on turbulent flow applied to boundary layer conditions on wing sections and to turbine blade blades p0184 N74 12642

## TURBULENT HEAT TRANSFER

Heat exchangers and forced convection turbulent heat transfer p0189 N72 18948

## TURBULENT MIXING

Turbulent shear stress models ranging from classical Prandtl mixing theory to kinetic energy models p0178 N72 20291

Turbulent mixing layer between two different streams to two dimensional flow p0178 N72 20295

## TURBULENT WAKES

Separation of a flow from thin bodies and the problem and associated problems as methods for measuring turbulent wake properties in hypersonic regimes p0178 N72 20296  
Laminar flow and transition from laminar to turbulent flow of passive wake in turbulent wake p0179 N72 20297  
Analysis of the effect of turbulence on the performance of aircraft and on the aerodynamic models of wing flow characteristics p0179 N72 20297  
Generation of aerodynamic noise by turbulent wake behind airfoils and airfoils in relation to drag and lift coefficients p0182 N73 20367  
Comparison of various methods for calculating the drag from pressure measurements on thin airfoils at subsonic speeds p0179 N74 14713  
The detection of air flow wake and the detection of air flow wake by means of laser Doppler velocimetry p0179 N74 14713  
Wake vortex flow field. Systems and methods for design and prediction of wake vortex flow field p0179 N74 14713  
Wake vortex flow field. Systems and methods for design and prediction of wake vortex flow field p0179 N74 14713  
Wake vortex flow field. Systems and methods for design and prediction of wake vortex flow field p0179 N74 14713

## TURKEY

Design and operation of Turkish information systems p0158 N73 24202

## TURNING FLIGHT

Development of methods for predicting aircraft flight maneuver and climb performance to show effects of excess power and load factor p0053 N73 24045

## TWILIGHT GLOW

Air to ground visibility of lights at low background levels p0303 N73 19987

## TWISTED WINGS

Wind tunnel tests to determine effects of blade twist and perpendicularity on rotor performance from hover to mach number 0.7 p0051 N73 21049

## TWO DIMENSIONAL BODIES

Distortion of grid generated turbulence in stagnation region of two dimensional body p0180 N72 20307

## TWO DIMENSIONAL FLOW

Two dimensional wind tunnel tests on airfoils with high lift devices p0025 N71 20056  
Aerodynamics of two dimensional flow on high lift systems p0027 N71 20057  
Coexistence of two dimensional and asymmetric flow in channel with constant cross section p0267 N72 16716  
Streamwise pressure gradient effects on two dimensional compressible turbulent boundary layers at high Reynolds number p0177 N72 20289  
Application of transport equation for Reynolds shear stress to calculating two dimensional flow in turbulent flow shear layers p0179 N72 20298  
Application of functional analysis to obtain exact semi-empirical solution of boundary layer flows under turbulent and laminar conditions p0041 N73 15003  
Development of two experimental approaches for analyzing two dimensional flow on high lift devices p0042 N73 15005  
Comparison of various methods for calculating profile drag from pressure measurements in the near wake at subsonic speeds p0020 N74 14721

## TWO REFLECTOR ANTENNAS

Some aspects of near and far angle sidelobe reduction in reflector antennas p0147 N74 13858

## U

## ULTRAHIGH FREQUENCIES

Cardinal and neutral effects of IMF solar energy on high frequency propagation p0048 N71 20354  
Very high frequency and ultra-high frequency propagation signal propagation models p0116 N71 21426  
Atmospheric ionospheric model for analyzing tropospheric ultra-high frequency signal fading p0118 N71 21456  
Coherence of atmospheric attenuation and rainfall effects on ultra-high frequency telecommunication systems [AGARD CP 102] p0140 N73 26121  
Multipath propagation and phase delay of ultra-high frequency radio wave caused by atmospheric discontinuities p0140 N73 26124  
Criteria for planning ultra-high frequency telecommunication systems considering absolute error and meteorological measurements p0141 N73 26129  
Horizontal radio line systems for measuring ultra-high frequency absorption spectrum due to rain p0141 N73 26130  
Ultra-high frequency effects of rain on signal transmission for different rain rates with measurements in the troposphere and upper atmosphere p0141 N73 26131  
Scattering in the ionosphere of ultra-high frequency radio waves due to rain p0141 N73 26133  
Point-to-point rate statistics for predicting propagation frequency ratio propagation p0142 N73 26135  
Multipath propagation measurements for planning ultra-high frequency radio link p0142 N73 26137  
Calculation of electromagnetic wave absorption by rain for frequencies above 30 GHz p0142 N73 26139  
Scattering attenuation of ultra-high frequency waves from rain-bearing clouds p0142 N73 26143  
Point-to-point point-to-point and point-to-point for ultra-high frequency signal transmission to rain p0142 N73 26141  
Long range frequency propagation effects of rain on communication systems by AFS weather methods and radar data p0143 N73 26142

## ULTRAHIGH VACUUM

Ultra-high vacuum for determining effects of high frequency radiation on the properties of materials p0281 N72 25916

## ULTRASONIC RADIATION

Measurement of ultrasonic wave propagation characteristics by computerized methods and data analysis p0144 N74 11919

## ULTRASONIC TESTS

Measurement of ultrasonic wave propagation characteristics by computerized methods and data analysis p0144 N74 11919

## ULTRAVIOLET RADIATION

Effects of ultraviolet radiation on the properties of materials p0144 N74 11919

## ULTRAVIOLET SPECTROMETERS

A new analysis of the properties of ultraviolet spectrometers p0144 N74 11919

## UNDERWATER ACOUSTICS

Analysis of remote Arctic ice pack sensing data obtained by submarine sonar airborne laser and infrared scanning imagery p0121 N72 16088  
Underwater acoustic beam width effects on signal scattering at rough surface of sea floor p0123 N72 16102

## UNDERWATER EXPLOSIONS

Lethal head injuries to man swimming underwater caused by detonation of firecracker p0100 N72 19135

## UNDERWATER OPTICS

Effects of resolution signal to noise ratio and contrast on underwater imaging systems performance p0242 N73 33631

Application of incoherent and coherent light sources for underwater illumination and comparison of efficiency for various conditions p0242 N73 33633

Characteristics of lenses and ports for underwater imaging systems to compare depth of field and relative aperture for several lens port combinations p0242 N73 33635

Techniques for long range visual underwater viewing range gating and dual scan with parallel techniques p0242 N73 33636

## UNDERWATER PHOTOGRAPHY

Application of optical filtering and image restoration to underwater photographs of floodlit images p0242 N73 33637

## UNITED STATES OF AMERICA

Equipment and facilities for modernizing research in US and Canada p0095 N71 23342

## UNSTEADY FLOW

Numerical analysis of aerodynamic loads on wing and tail surfaces with oscillations in unsteady supersonic and subsonic flow including interference lift [AGARD CP 80 71 PT 1] p0007 N71 29333  
Aerodynamic load prediction for control surfaces in unsteady supersonic and subsonic flow p0007 N71 29334  
Wing interference lift from lattice simulation and application to aerodynamic loads on tandem wings in unsteady flow p0008 N71 29336  
Symposium on unsteady aerodynamic loads and configurations for aerodynamic analysis of interdigital surfaces [AGARD CP 80 71 PT 2] p0008 N71 29338

Characteristics of subsonic unsteady airloads on multiple thin surfaces p0008 N71 29339

Unsteady pressure measurements on a wing in unsteady flow p0008 N71 29340

Oscillating swept wing with two dimensional flow in incompressible flow p0010 N71 29350

Three dimensional methods for first order Stokes equations for two and three dimensional unsteady flow p0181 N72 22296

Unsteady flow of viscous incompressible fluid in bounded domain p0181 N72 22297

High speed wake in form of planing flow in transonic turbulent wake p0271 N73 19818

Analysis of unsteady aerodynamic environment of totally wing and research projects to improve understanding of unsteady aerodynamics p0050 N73 21041

Comments on NASA Langley research on transonic unsteady aerodynamics flutter calculations methods [NASA TM X 69997] p0023 N74 18652

Interfering thin surfaces in unsteady subsonic flow. Comparison between theory and experiment [AGARD R 614] p0023 N74 18654

## UNSWEEP WINGS

Method for estimating transonic buffet boundary and Reynolds number effects for straight and swept wings p0011 N72 11857

Transonic swept wing effects of effectiveness of high lift devices on swept and straight wings in rolling flow separation p0012 N72 11860

## UPPER ATMOSPHERE

Particle precipitation in polar upper atmosphere p0126 N72 21122

Radar observations of meteor trails for detecting high altitude gravity waves p0137 N73 14154

## URINALYSIS

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Urinalysis methodology for detection of abusive and therapeutic drug use p0081 N73 21117

Protein excretion by the kidney p0081 N74 13802

Rapid mixing nozzles thrust vector control and thrust augmentation for V/STOL aircraft p0285 N72 16699

Stability and control flight test procedures for V/STOL aircraft in general and specific application to P-1127 and Harrier aircraft p0335 N72 20980

Design problems of inlets and nozzles used in supersonic and V/STOL propulsion systems p0287 N72 21819

Design guidelines for pictorial integrated flight control and guidance displays for V/STOL aircraft p0224 N72 22630

V/STOL display requirements for approach and landing under adverse weather conditions p0224 N72 22632

Proceedings of conference on handling qualities and performance criteria for conventional and V/STOL aircraft [AGARD CP 108] p0338 N72 32017

Remedies to handling qualities criteria for V/STOL aircraft with emphasis on instrument flight characteristics p0338 N72 32021

Development of V/STOL aircraft handling qualities criteria specification and analysis of deficiencies p0338 N72 32022

Display systems for all weather minimal operational capability of V/STOL aircraft p0196 N73 11407

Revisions to V/STOL handling qualities based on criteria p0044 N73 16994

Analysis of aircraft instruments and display devices for approach control and landing of V/STOL aircraft [AGARD AR 51] p0196 N73 18439

Proceedings of conference on rotary wing aircraft developments to include operational experience, flight tests and evaluation of structural concepts p0046 N73 21008

Aerodynamic dynamic and aerelastic problems in rotary wing design for helicopters and V/STOL aircraft with application to hingeless rotor systems p0051 N73 21051

Analysis of factors involved in design of wind tunnel for testing V/STOL aircraft models p0018 N73 22956

Analysis of operational problems associated with wind tunnel testing of V/STOL aircraft and helicopters p0173 N73 26240

Scaling laws, constructional problems, and optimum model size associated with wind tunnel tests of helicopters and rotary wing aircraft p0173 N73 26246

Proceedings of conference on military applications of V/STOL aircraft to include current and proposed research projects to meet military requirements [AGARD CP 126 VOL 1] p0054 N73 27000

Review of V/STOL aircraft research and development programs to increase effectiveness of aircraft and develop mission improvements p0054 N73 27001

Review of V/STOL development programs to compare basic characteristics of KC-142A, X-19 and X-22A aircraft under various flight conditions p0054 N73 27003

Design development and characteristics of Do 31 V/STOL aircraft to include solution of operational problems caused by ground effect and transition flight p0054 N73 27004

Design development and flight characteristics of VAK 191 B V/STOL strike reconnaissance aircraft p0054 N73 27006

Handling characteristics of V/STOL aircraft based on data obtained from flight tests, simulator operation and analytical studies [AGARD R 577 PT 2] p0055 N73 27906

Development of method for calculating near field noise level in free jet and influence of ground effect on noise produced by V/STOL aircraft operation p0292 N73 29907

**VANADIUM**

Corrosion resistant materials for nozzle guide vanes and turbine blades subject to vanadium containing fuel combustion p0203 N73 23613

**VANELESS DIFFUSERS**

Method for prediction of turbulent boundary layer flow in vaneless radial diffuser and experimental validation p0270 N73 19809

**VAPORIZING**

Vaporization thermodynamics of Cr2O3 protective scales under transient flow conditions p0202 N73 23507

**VARIABLE GEOMETRY STRUCTURES**

Interfering lifting surfaces in unsteady, subsonic flow: Comparison between theory and experiment [AGARD R 614] p0023 N74 18654

**VARIABLE SWEEP WINGS**

Aerodynamics of variable sweep aircraft design p0025 N73 20054

**VARIATIONS**

Use of psychometric tests to account for subjective variations in operations performance relative to target acquisition p0304 N73 19974

Importance of the 4-5 c/sec rhythm in the EEG to determine military flying fitness: psychologic factors in EEG patterns p0086 N74 13797

**VEGETATION**

Ultrahigh frequency antenna scatter propagation distribution by vegetation p0119 N73 23461

Interpretation of side looking airborne interferometry for vegetation mapping [NASA CR 125451] p0122 N72 16792

**VELOCITY DISTRIBUTION**

Velocity distribution at supersonic compressor inlet in wind tunnel tests p0267 N72 16713

Velocity distribution measurement of subsonic asymmetric inlet for compressor matching p0287 N72 16714

Temperature fluctuations and spectral distributions for temperature and velocity in turbulent boundary layer p0175 N72 20278

Procedures for measuring velocity distribution through helicopter rotor blade tip vortex using single full scale rotor blade p0049 N73 21034

**VELOCITY MEASUREMENT**

Procedures for measuring velocity distribution through helicopter rotor blade tip vortex using single full scale rotor blade p0049 N73 21034

Computer electronystagmography in evaluating the influence of psycho pharmacological drugs on vigilance p0109 N74 20749

**VERTEBRAL COLUMN**

Nonfatal syphilitic vertebral fracture comparison between US British and Swedish armed services p0083 N73 23059

The risk of minor spinal abnormalities in aircrews: Evaluation of aviation cases p0084 N74 13795

**VERTICAL FLIGHT**

Parameters for enhancing performance of helicopter rotors during stationary flight p0049 N73 21038

**VERTICAL LANDING**

Evaluation of integrated flight display for hovering phase of IFR landing of VTOL aircraft p0224 N72 22631

**VERTICAL TAKEOFF AIRCRAFT**

Military applications of V/STOL aircraft Volume 2 [AGARD CP 126 VOL 2] p0082 N74 73507

Possibilities and limitations of rotary and fixed wing compatible Doppler sensor designs p0031 N72 11923

Propulsion jet flow for vertical takeoff aircraft p0285 N72 16700

Evaluation of integrated flight display for hovering phase of IFR landing of VTOL aircraft p0224 N72 22631

Structural concepts of rotary wing system capabilities to show changes in design of specific vertical takeoff aircraft components p0048 N73 21021

Development and application of composite materials for vertical takeoff aircraft airframes and effect on improved aircraft performance p0048 N73 21023

Aerodynamic characteristics of cyclically controlled rotor and fundamental problems of stressed rotor aircraft p0048 N73 21024

Development of jet flap rotor and application to heavy helicopter and stoppage rotor designs p0048 N73 21025

Development of rotary wings with cold hot and mixed cycle tip jet propulsion systems and application for torque free rotor drive system p0048 N73 21026

**VERTIGO**

Proceedings of conference on medical aspects of spatial disorientation and effects on safe aircraft operation [AGARD CP 95 PT II] p0071 N72 25031

Analysis of spatial disorientation reports by flying personnel during 14 year period [NASA CR 126786] p0071 N72 25032

Analysis of spatial disorientation occurrences among military pilots and classification according to types of aircraft and nature of accidents p0071 N72 25033

Analysis of military aircraft accidents caused by spatial disorientation p0071 N72 25034

Statistical analysis of military aircraft accidents to determine incidents caused by spatial disorientation p0071 N72 25035

Psychophysiological and environmental factors involved in aircraft accidents of military aircraft and effect of flying experience in reducing spatial disorientation p0071 N72 25036

Effects of high intensity noise levels on human vestibular system and production of disorientation and dizziness [AMRL TR 71 58] p0072 N72 25038

Analysis of aircraft pilot reports on occurrence of unsteady flight and detachment during flight and relationship to spatial disorientation p0072 N72 25042

Occurrences of vertigo in hyperbaric atmospheres and among underwater divers with theoretical explanations of etiology involved p0072 N72 25043

Development of procedures for exposing aviators to effects of spatial disorientation in ground based simulator p0073 N72 25045

Application of methods of simulation of instrument flying as means of reducing occurrence of spatial disorientation in flight p0073 N72 25046

Clinical evaluation and medical treatment of spatial disorientation problems in flying personnel p0073 N72 25047

Altitude for recovery from vertigo in flying personnel p0074 N72 25059

Vertigo in diving p0110 N74 20753

**VERY HIGH FREQUENCIES**

Very high frequency and ultrahigh frequency transmission signal propagation modes p0116 N71 21428

**VESTIBULAR TESTS**

Physiologic tests of vestibulo ocular reflex by counterroll to determine effects of positive acceleration on dynamics of vestibular system of human subjects [AMRL TR 71 59] p0072 N72 25040

The use of nystagmography in aviation medicine: semispace medicine meeting in nystagmus p0107 N74 20742

Prostatic problems in clinical nystagmography: 2 Sources of error p0108 N74 20735

Use of nystagmography in the study of aircrew with spatial disorientation: oculographic testing of flight crews p0108 N74 20736

Interest of nystagmography in flying navigation personnel p0108 N74 20738

A contribution to the electronystagmographic method concerning the interpretation of nystagmus characteristics: vestibular tests to assess motion sickness and disorientation susceptibility p0108 N74 20739

Differential diagnosis of the caloric nystagmus: qualitative characteristics of labyrinthine or CNS abnormalities p0108 N74 20740

Otolithic nystagmus: its value in the diagnosis of certain vestibular lesions: human abnormal neurophysiological responses in the presence of brain stem lesions p0109 N74 20742

Visual vestibular interaction: The role of the labyrinth in the production of optokinetic nystagmus and optokinetic after nystagmus: effects of labyrinthectomy on eye movements in optical tracking task p0109 N74 20743

Self motion sensation pseudo corollis effects and motion sickness induced by optokinetic stimuli: psychophysiological experiments on human motion perception p0109 N74 20744

Effects of sound on the vestibular system: of guinea pigs and monkeys p0109 N74 20745

Aeromedical research and clinical applications of averaging techniques in nystagmography: computer techniques for precise measurements of average eye movements p0110 N74 20750

**VESTIBULES**

Cochlear and vestibular injuries during diving: inner ear damage and auditory deficits p0110 N74 20754

**VHF OMNIRANGE NAVIGATION**

Integrated SAVVAN VOR and DME system for locating and controlling high altitude aircraft p0232 N73 23895

**VIBRATION EFFECTS**

Vibration effects on performance of helicopter flight crews p0089 N71 20355

Environmental tests of V/STOL vibration effects on human comfort [NASA TM C 66956] p0088 N71 20356

Analysis of response and fatigue characteristics of light alloy integrally machined plants with emphasis on acoustic fatigue properties p0293 N73 29912

Analysis of structural response to acoustic loading and preparation of data sheets for various conditions of acoustic loads p0293 N73 29914

PGA: Acceleration tests on vertical VCC 3 beta: centrifuge and vibration tests of inertial guidance systems p0236 N74 14347

**VIBRATION TESTS**

Development of method for determining response of box type structures subjected to high intensity acoustic loading p0293 N73 29915

**VIBRATIONAL STRESS**

Structural vibration and noise effects on man in aerospace operations [AGARDOGRAPH 151] p0076 N73 17098

**VIDEO DATA**

Video storage and transmission systems for documentation and dissemination of information: conference [AGARD CP 92] p0157 N72 27169

**VIDEO EQUIPMENT**

Advanced digital visual communication systems for television transmission and video storage p0158 N72 22172

**VISCOUS DAMPING**

Analysis of effect of damping on response of structure to acoustic excitation and experimental method for determining damping coefficients p0293 N73 29917

**VISCOUS DRAG**

Reynolds number effects in viscous inviscid interactions on transonic swept wings p0011 N72 11855

**VISCOUS FLOW**

Existence of velocity potential for viscous fluid flow and role of compressibility in turbulent subsonic or supersonic flow p0176 N72 20282

Numerical analysis of viscous gas flow and shock formation p0181 N72 27309

Extension of time dependent technique for viscous blunt body flow to viscous flow p0182 N72 27303

Development of procedure for determining characteristics of high lift systems where viscous effects dominate p0042 N73 15009

Effect of axial velocity ratio on aerodynamic coefficients of compressor cascade in viscous flow p0269 N73 19804

Development of techniques for analyzing boundary layer characteristics of rotary wings based on unsteady viscous flow interaction p0061 N72 21040

**VISCOUS FLUIDS**

Nonstationary flow of viscous incompressible fluid in bounded domain p0181 N72 27297

Navier Stokes equations of viscous incompressible fluid in bounded domain p0181 N72 27299

**VISIBILITY**

Effects of various parameters on long range underwater vision for narrow and broad beam illuminators p0247 N73 33630

**VISION**

Drug effects on vision of flying personnel p0082 N73 21121

## SUBJECT INDEX

### VISUAL ACCOMMODATION

Semi-control infrared optometer applied to study of voluntary control of human visual accommodation  
[NASA TM X 69555] p0070 N71 20771

### VISUAL ACUITY

Naval research on laser caused visual acuity decrement in monkeys and ocular injury in humans  
p0076 N72 26056

AGARD conference on air to ground target acquisition [AGARD CP 100] p0302 N73 19959

Peripheral acuity with complex stimuli at two viewing distances  
p0303 N73 19965

Air to ground target acquisition with flare illumination  
p0303 N73 19968

### VISUAL PERCEPTION

Human perceptual characteristics data relating to individual electronic flight display design  
p0273 N72 21622

Application of extra focal vision to predicting target acquisition in air to ground search  
p0302 N73 19960

Modeling of random human visual search performance based on physical properties of eye  
p0302 N73 19961

Modeling prediction of probability of acquiring designated target as function of its range as target is approached  
p0302 N73 19962

Calculation and simulation of effects of complex scene similarity  
p0302 N73 19963

Relationship between subjective effect of structured target backgrounds on acquisition performance  
p0303 N73 19964

Model for where it contrast conditions in full form objects  
p0303 N73 19966

Biometrical problems with helmet mounted sight in visual target acquisition system  
p0303 N73 19969

### VISUAL STIMULI

Peripheral acuity with complex stimuli at two viewing distances  
p0303 N73 19965

Optokinetic nystagmus: its value in the diagnosis of reticular vestibular lesions  
p0309 N74 20742

Visual vestibular interaction: The role of the labyrinth in the production of optokinetic nystagmus and optokinetic after nystagmus  
p0309 N74 20743

### VISUAL TASKS

Air to ground visibility of lights at low background levels  
p0303 N73 19967

### VJ-101 AIRCRAFT

Flight maneuver problems in ground investigations for VJ-101 aircraft  
p0330 N71 23428

Analysis of aerodynamic characteristics of VJ-101 and DO-31E V-STOL aircraft and comparison with criteria contained in handling requirements documents  
p0339 N72 32024

### VOICE

Processing and display of time varying spectral information with application to sonar voice and radar signals  
p0154 N72 11200

### VOICE COMMUNICATION

Numerical control of delta modulated vocal signals in an navigation telecommunication system  
p0131 N73 10194

### VORTEX GENERATORS

Safety measures to eliminate aircraft trailing vortex hazards  
[NASA TM X 67125] p0028 N71 2341b

### VORTEX SHEETS

Development of procedure for determining geometry and strength distribution of vortex wake generated by single bladed hovering helicopter rotor  
p0449 N73 21035

### VORTICES

Wind tunnel vortex flow study in study of revolution with or without wing  
p0001 N71 19355

Procedures for measuring velocity distribution through helicopter rotor blade tip vortex using a wake full scale rotor blade  
p0049 N73 21034

The detection of aircraft wake vortices: development of acoustic and wind pressure sensors for vortex detection  
p0358 N74 17731

Vortex wake research in flight investigation of aircraft wake generated by C-5 aircraft  
p0359 N74 17733

### VULNERABILITY

Physical vulnerability of aircraft volume 1  
[AGARD AR 47 VOL 1] p0061 N74 23501

Physical vulnerability of aircraft volume 2  
[AGARD AR 47 VOL 2] p0061 N74 23501

Aircraft vulnerability analysis volume 3  
[AGARD AR 47 VOL 3] p0061 N74 23502

## W

### WAKES

Turbulent boundary layers jets and wakes: comparisons  
[AGARD CP 93] p0175 N72 20273

### WALL FLOW

AGARD report on engine airframe interference and wall conditions in transonic wind tunnel tests  
[AGARD AR 36 71] p0510 N73 36400

Experimental studies of flow distribution near wall in turbulent boundary layer  
p0175 N72 20275

Burst distribution near reattachment of wall region and turbulent boundary layer  
p0175 N72 20277

Approximation of two dimensional turbulent boundary layer under arbitrary wall and free flow conditions  
p0176 N72 20279

Analysis of laminar part of separation bubbles in two dimensional incompressible flow for various shaped objects  
p0041 N73 15000

Development of numerical methods for correcting wall constraints in transonic wind tunnels with ventilated walls  
p0173 N73 26241

### WALL TEMPERATURE

Coupling effects between wall heating and axial pressure gradients in turbulent boundary layer flow  
[NASA CR 125903] p0176 N72 20281

### WATER

Effects of positive G<sub>y</sub> acceleration on blood oxygen saturation and pleural pressure relations in dogs breathing air and liquid fluorocarbons in whole body water immersion respiration  
[NASA CR 117199] p0068 N71 20358

Electrical conductance measurements for determining stress-strain time life of glass fiber to resin interlaminar bond in reinforced plastic materials exposed to water  
p0208 N72 12505

### WATER POLLUTION

Feasibility of treating international monitoring position information analysis center  
p0113 N71 19532

### WATER VAPOR

Water evaporation interference in phase measurements by transmittance in microwave propagation over sea surface  
p0140 N73 26125

### WAVE AMPLIFICATION

Introductory survey to sea surface propagation over irregular terrain  
p0145 N74 13847

### WAVE DEGRADATION

The radiation diagrams of antennas used in terrestrial microwave free of light systems  
p0147 N74 13359

### WAVE DIFFRACTION

Radio wave diffraction due to a mountain of volcanic origin  
p0146 N74 13651

Wave diffraction in the ocean due to topographic effects at frequencies between 180 MHz and 10 GHz in the vicinity of a terrain  
p0146 N74 13852

### WAVE EXCITATION

Mathematical model for acoustic gravity wave excitation moving air masses  
p0134 N73 14135

### WAVE FRONT RECONSTRUCTION

Reconstruction of topographic features from topographic data of flying aircraft  
p0199 N72 25495

### WAVE PROPAGATION

Characteristics and effects of Arctic ionosphere on radio and radar propagation  
[AGARD CP 97] p0126 N72 21121

Power spectral densities, Doppler shifts, and phase fluctuations of frequency distortion in an HF propagation  
p0129 N72 21143

Effects of Arctic ionosphere characteristics on radio and radar propagation  
[AGARD AR 33] p0130 N72 2213b

Comparison of ionospheric wave propagation and acoustic gravity wave propagation  
p0134 N73 14132

Ray tracing method for calculating propagation of gravity waves in atmosphere  
p0134 N73 14133

Asymptotic methods for determining propagation of gravity waves in atmosphere  
p0136 N73 14144

Delay in propagation of radio waves due to ionospheric irregularities  
p0241 N73 33629

Rate of atmospheric effects in the propagation of ionospheric wave propagation  
p0145 N74 13849

Effect of terrain screening on radar wave propagation of propagation  
p0146 N74 13850

Propagation survey for version 4: Propagation data for the future in probability determinations  
p0147 N74 13851

### WAVE REFLECTION

Ionospheric disturbance effects on sky wave heating measurement  
p0138 N73 14159

The behavior of very high field strengths at beyond the frequency propagation over sea surface  
p0147 N74 13853

### WAVEFORMS

Design waveform classification tests by interactive machine methods  
p0154 N72 11202

### WAVE JIDES

A computer program for analyzing wave propagation  
p0156 N74 13919

### WEAPON SYSTEMS

Role of simulations in the study and development of the CRISTAL system ground to air defense weapons system  
p0277 N74 14355

### WEAPONS DEVELOPMENT

Application of control system requirements to development of tactical missile weapons systems  
p0270 N72 27003

### WEATHER

Weather factors in tactical flight performance studies  
p0130 N71 23431

### WEATHER DATA RECORDERS

Radiation measurement for aircraft flight performance in microwave frequency meteorological data  
p0142 N71 26115

## WIND TUNNEL APPARATUS

### WEIGHTLESSNESS SIMULATION

Human eye movements during various forms of linear acceleration and weightlessness: effects of cinematographic recordings of human and fish responses to gravitational conditions  
p0109 N74 20747

### WELDED JOINTS

Nondestructive tests and their application for inspection of adhesive bonded structures welded joints and riveted or bolted joints  
p0197 N72 19542

Microstructure and stress corrosion behavior of welded steel joints  
p0286 N72 21910

Failure of welded joints in T. Al-Si-Mg type alloys in CO<sub>2</sub> vapor  
p0289 N72 21929

### WESTLAND AIRCRAFT

Flight tests of Westland Scout helicopter fitted with reduced scale version of rotor to determine airworthiness and handling characteristics  
p0047 N73 21017

### WETTABILITY

Photoelastic measurement of monoflamme wetting by reinforcing resins of composite materials  
p0208 N72 12506

### WHIPLASH INJURIES

Three primate species undergoing whiplash injuries  
p0099 N72 19127

### WHISKER COMPOSITES

Application of directionally solid fiber whiskers for design and construction of gas turbine engines  
p0212 N73 27493

Directional solidification of eutectic alloys and application to turbine blades and gas turbine engine components  
p0213 N73 27494

Application of glass and carbon fiber reinforced structures for gas turbine engine components to operate at high temperature environments  
p0213 N73 27495

### WIDEBAND COMMUNICATION

Tropospheric characteristics and their effects on detection, agnetic wave propagation and radio signal transmission [AGARD CP 70 71 PT 1] p0114 N71 21409

Improved tropospheric wave propagation for military applications  
p0114 N71 21410

Statistical evaluation of fading caused by time modulation in combined long wave broadband propagation [ICNET NT EST APH 1] p0117 N71 21433

Wideband tactical satellite communications systems using onboard processing  
p0132 N73 10202

### WIND (METEOROLOGY)

Review of data and prediction techniques for wind profiles around manmade surface obstructions: summary of analytical models and computational procedures  
p0057 N74 17724

### WIND EFFECTS

Problems in the simulation of atmospheric boundary layer flows in natural wind environment in atmospheric boundary layer for aerospace and aeronautical applications  
p0057 N74 17722

Review of data and prediction techniques for wind profiles around manmade surface obstructions: summary of analytical models and computational procedures  
p0057 N74 17724

### WIND PRESSURE

Effects of G forces on human during eye motion extraocular eye motion  
p0102 N72 19145

Performance tests of protective clothing in determining effect versus against air blast during high speed impact  
p0102 N72 19147

Traveling atmospheric disturbance generation by tropospheric wave  
p0136 N73 14147

### WIND PROFILES

Review of data and prediction techniques for wind profiles around manmade surface obstructions: summary of analytical models and computational procedures  
p0057 N74 17724

### WIND TUNNEL APPARATUS

Performance characteristics of high Reynolds number wind tunnel  
[NASA TM X 67419] p0015 N72 11882

Analysis of factors involved in design of wind tunnel for testing V-STOL aircraft models  
p0018 N73 22956

A study of problems involved in operation of large wind tunnel at subsonic and supersonic speeds  
[AGARD R 501] p0172 N73 26239

A study of interference in wind tunnel tests of aircraft models  
p0173 N73 26242

Objective of dynamic tests in low speed wind tunnel and the frequency of measurement and the frequency of measurement  
p0173 N73 26244

A study of the frequency of measurement and the frequency of measurement  
p0173 N73 26244

Test of jet aircraft engine in low speed wind tunnel  
p0173 N73 26244

Assessment of the influence of order and direction of performance on the aerodynamic  
p0271 N74 14376

Study of interference effects on afterburner air flow speeds  
p0272 N74 14377

Some considerations of future low speed tunnels for engine  
p0273 N74 14378

Proposed study of large scale engine tests in low speed wind tunnel  
p0273 N74 14378

The development of aircraft and engine tests in low speed wind tunnel  
p0273 N74 14378

Test of jet aircraft engine in low speed wind tunnel  
p0273 N74 14378

Test of jet aircraft engine in low speed wind tunnel  
p0273 N74 14378

Test of jet aircraft engine in low speed wind tunnel  
p0273 N74 14378

Test of jet aircraft engine in low speed wind tunnel  
p0273 N74 14378

Test of jet aircraft engine in low speed wind tunnel  
p0273 N74 14378

Test of jet aircraft engine in low speed wind tunnel  
p0273 N74 14378

## WIND TUNNEL DRIVES

### WIND TUNNEL DRIVES

Some considerations of future low speed tunnels for Europe p0173 N74 16988  
Project study of a large European transonic Luchwing Tube wind tunnel p0174 N74 16989  
The development of an efficient and economical system for the generation of quiet transonic flows suitable for model testing at high Reynolds number p0174 N74 16990  
The injector driven tunnel p0174 N74 16991  
Facilities for aerodynamic testing at hypersonic speeds p0174 N74 16993

### WIND TUNNEL MODELS

Wind tunnel tests with jet simulation of teaplane interference on European Airbus models p0004 N71 19374  
Photographic recording of aerodynamic interference in wind tunnel simulation of pitchonned drop loads from aircraft p0005 N71 19378  
Three dimensional testing of high lift device models p0026 N71 20057  
Conference on theoretical methods and wind tunnel facilities for transonic aerodynamic testing of aircraft at high Reynolds numbers p0011 N72 11854  
Flow model for shock induced leading edge transonic flow (turbulence and rear separation in low speed state) of airfoil p0011 N72 11858  
Feasibility of transonic wind tunnel testing of large cord swept wing panel model for simulating wing shock location at flight Reynolds number p0013 N72 11870  
Wind tunnel model boundary layer reduction through suction for accurate simulation of high Reynolds number full scale aircraft characteristics p0014 N72 11875  
Methods for solving engine airplane interference and wall corrections in transonic wind tunnel tests for predicting aerodynamic performance of airplane design p0014 N72 11877  
Specifications for high Reynolds number wind tunnel design for flow simulation in swept wing aircraft development test p0015 N72 11883  
Transonic wind tunnel model measurements of buffet loads and boundaries at various sweep and aspect ratio wing roots p0016 N72 11886  
Transonic wind tunnel design for model testing at high Reynolds number p0016 N72 11887  
Engine airplane interference corrections in calculating model aircraft performance from wind tunnel test data p0037 N72 27017  
Wind tunnel test requirements for simulating nozzle parameters and nozzle airframe interference characteristics p0037 N72 27021  
Application of blockage correction factors to wind tunnel test measurements on aircraft models p0042 N73 15006  
Development of advancing blade concept rotary wing and wind tunnel tests of full scale model p0048 N73 21029  
Wind tunnel tests to determine effects of blade twist and aerodynamic on tilt rotor performance from hover to mach number 0.7 p0051 N73 21049  
Wind tunnel tests to determine effects of nonrotating components on helicopter performance and application for helicopter design optimization p0051 N73 21052  
Procedures for testing rotary wing aircraft models in wind tunnels to include design of test facilities, cost of models and facilities and methods for obtaining data p0018 N73 22955  
Analysis of factors involved in design of wind tunnel for testing V-STOL aircraft models p0018 N73 22956  
Aerodynamic coefficients for calculating transport aircraft performance using wind tunnel and scale models p0053 N73 24046  
Analysis of operational problems associated with wind tunnel testing of V-STOL aircraft and helicopters p0173 N73 26240  
Analysis of interference occurring in subsonic and transonic wind tunnels caused by model support system p0173 N73 26242  
Analysis of techniques and equipment required to conduct test of jet aircraft engine models in wind tunnels p0173 N73 26245  
Scaling laws, constructional problems, and optimum model size associated with wind tunnel tests of helicopters and rotary wing aircraft p0173 N73 26246  
**WIND TUNNEL STABILITY TESTS**  
Two dimensional wind tunnel tests of a delta with high lift devices p0025 N71 20055  
Three dimensional testing of high lift device models p0026 N71 20057  
Transonic wind tunnel tests of effectiveness of high lift devices on swept and straight wings in control up flow separation p0027 N72 11889  
Transonic wind tunnel testing for predicting flight performance characteristics of aircraft p0113 N72 11865  
Correlation of transonic wind tunnel test data with flight test results on slender wing airplanes for double delta configuration development p0013 N72 11868  
Comparison of wind tunnel and flight test results for determining full scale aerodynamic flight data limits [NASA TM X 67413] p0013 N72 11869  
Methods for solving engine airplane interference and wall corrections in transonic wind tunnel tests for predicting aerodynamic performance of airplane design p0014 N72 11877

Aerodynamic suitability of Freon 12 for wind tunnel testing of transport aircraft models at increasing Reynolds numbers and subcritical and supercritical Mach numbers [NASA TM X 67417] p0015 N72 11879  
Hydraulic equipment for high Reynolds number testing in transonic wind tunnel [NASA TM X 67418] p0015 N72 11880  
Flow distortion and performance measurements on 12 in fan-in-wing model for range of forward speeds and angle of attack settings in closed wind tunnel p0285 N72 16702  
Controller, independent of other intake controllers and aircraft data systems and wind tunnel testing of supersonic intake control system p0286 N72 16706  
External drag characteristics of jet engine exhaust nozzles using wind tunnel tests p0286 N72 16707  
Velocity distribution at supersonic compressor inlet in wind tunnel tests p0287 N72 16713  
Comparison of flight test and wind tunnel data to determine areas of agreement when non-linearities appear in aerodynamic coefficients of slender wing aircraft p0036 N72 20990  
Wind tunnel tests to obtain pre-flight estimates of stall speed and low air speed performance of Boeing 747 aircraft p0043 N73 15016  
Procedures for testing rotary wing aircraft models in wind tunnels to include design of test facilities, cost of models and facilities and methods for obtaining data p0018 N73 22955

### WIND TUNNEL TESTS

Predicting flying qualities by wind tunnel tests p0045 N73 17000  
Analysis of operational problems associated with wind tunnel testing of V-STOL aircraft and helicopters p0173 N73 26240  
Analysis of minimum run times required for instantaneous measurements at transonic speeds during wind tunnel tests p0173 N73 26243  
Objectives of dynamic tests in low speed wind tunnels and techniques for measuring oscillatory derivatives and transient motion effects p0173 N73 26244  
Analysis of techniques and equipment required to conduct test of jet aircraft engine models in wind tunnels p0173 N73 26245  
Scaling laws, constructional problems, and optimum model size associated with wind tunnel tests of helicopters and rotary wing aircraft p0173 N73 26246  
Analysis of acoustic factors involved in wind tunnel tests to show contributions from various sources p0173 N73 26247  
Influence of free stream turbulence on turbulent boundary layer in relation to wind tunnel testing at subsonic speeds p0184 N73 26283  
Measurements of the drag of some characteristic aircraft extraneous immersed in turbulent boundary layers p0019 N74 14714  
Problems of estimating the drag of a helicopter: correlation of flight test data and scale model test data p0019 N74 14715  
Transonic drag due to lift of planar jet flapped airfoils p0020 N74 14720  
Spreading interference effects on attributes at transonic speeds p0022 N74 14737  
**WIND TUNNEL WALLS**  
Development of numerical methods for correcting wall constraints in transonic wind tunnels with ventilated walls p0173 N73 26241

### WIND TUNNELS

Survey of wind tunnel testing procedures for nozzles and exhausts p0263 N72 16688  
Wind tunnel tests of afterbody thrust and correction for models with simplified hollow nozzles p0263 N72 16689  
Development and characteristics of flow Doppler velocity instrument to measure velocities of flowing fluids p0290 N73 25505  
Development and characteristics of dual scatter laser Doppler velocimeter for flow distribution measurement in wind tunnels, helicopter down wash, and across high lift wing sections p0290 N73 25506  
Developments in aerodynamic test facilities to show past experience, present status, free flight techniques and future plans [AGARD R 603] p0172 N73 19250  
Existing position and future prospects of wind tunnels in European research p0172 N73 20269  
Analysis of operational problems associated with wind tunnel testing of V-STOL aircraft and helicopters p0173 N73 26240

### WIND FLAPS

High lift wing flap tests using wind tunnel planar flap and secondary layer control and wing with flap and high lift device extended p0027 N71 20065

### WING LOADING

Effect of tail fin wing load distribution on lateral and longitudinal maneuverability of aircraft p0044 N73 16996

### WING OSCILLATIONS

Dynamic analysis of aircraft model oscillations in subsonic flow with oscillations in gusty air and subsonic flow with gusty air p0007 N71 19313  
Buckling analysis of thin airfoil in gusty air p0008 N71 19317

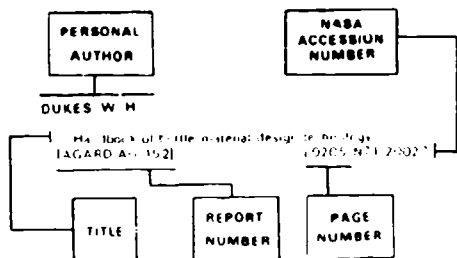
## SUBJECT INDEX

Calculated values of air forces on oscillating thin wings obtained by linearized potential flow p0010 N71 35198  
[AGARD R 583 71] p0010 N71 35198  
Calculation and measurement of aerodynamic loading on oscillating airfoil with and without aerodynamic tailing p0050 N73 21042  
On the prediction of aerodynamic loads on oscillating wings in transonic flow p0023 N74 18653  
[AGARD R 613] p0023 N74 18653  
**WING PLANFORMS**  
Development of algorithm for calculating inviscid flow about arbitrary planform rotors and application to analyzing various rotary wing configurations p0051 N73 21048  
Aerodynamic characteristics of high lift wing concept for application to commercial short takeoff transport aircraft p0292 N73 29308  
New investigations for reducing the base drag of wings with a blunt trailing edge effects of splitter plates and splitter wedges on aerodynamic drag coefficients p0020 N74 14723  
**WING PROFILES**  
Transonic wind tunnel determination of blunt trailing edge effects on drag and lift characteristics of wing profile p0012 N72 11862  
**WING FUSELAGE STORES**  
Aerodynamic interference characteristics of a frame propulsion systems of transport and military aircraft p0001 N71 19353  
[AGARD CP 71 71] p0001 N71 19353  
Aerodynamic interference effects between wing and fuselage junctions p0001 N71 19354  
Wind tunnel surveys of flow fields about wing fuselage store configuration inlets of transonic and supersonic aircraft p0004 N71 19371  
[NASA TM X 66885] p0004 N71 19371  
Aerodynamic configuration effects of propulsion system integration into supersonic transport design p0004 N71 19373  
Wind tunnel evaluation of interference drag in turbulent engine wing configuration of subsonic aircraft p0004 N71 19376  
Flow field interference beneath swept wing fuselage store installation on aircraft p0005 N71 19380  
Computerized prediction of interference flow field for wing fuselage store location on bomber aircraft p0005 N71 19381  
Wind tunnel studies of external store induced flow field instability effects on longitudinal stability of arrow wing aircraft p0005 N71 19382  
External store interference caused by rocket launch pod positioning on aircraft wing p0006 N71 19387  
Procedures for calculating normal wash in nonplanar configurations and interference between wings and bodies p0008 N71 29340  
**WINGED VEHICLES**  
Wind tunnel vortex flow study on body of revolution with or without wings p0001 N71 19355  
**WINGS**  
Computer programs for evaluating subsonic flow over wing tail wings with loaded tips, T-tails, and cruciform tail surfaces p0009 N71 29341  
Method for calculating flutter using interference aerodynamic forces between wing and tail p0009 N71 29345  
Calculation of pressure distributions over wings with harmonic oscillating control surfaces using kernel function method p0009 N71 29346  
Application of lifting surface theory to wing with control surfaces in steadily subsonic flow p0009 N71 29347  
Asymptotic expansion techniques to define pressure loading effects on wings with unbalanced control surfaces p0010 N71 29348  
Forebody and forebody wing configuration data for supersonic inlet performance and distortion during maneuvering flight p0286 N72 16710  
**WIRE**  
Tensile strength measurements on steel wire reinforced aluminum alloys p0208 N72 12501  
Explosive bonding technique for strengthening aluminum with titanium wires p0208 N72 12502  
**WORK CAPACITY**  
Oxygen consumption and work capacity in fitness evaluations on Canadian Armed Forces personnel p0092 N71 22311  
Health hazards and efficiency reductions of personnel exposed to simulated nuclear strike waves on profile free shelters p0100 N72 19136  
**WORK REST CYCLE**  
Automatic analysis of ECG in rest, during and after exercise with two computer systems p0073 N72 25052  
**X**  
**XH 51 HELICOPTER**  
Flying safety factors in use for ground operations of XH 51 helicopter p0034 N71 23431  
Flight tests of XH 51 helicopter to determine effects of gyroscopic and control spring fluctuations on stability and control p0047 N73 21015

# PERSONAL AUTHOR INDEX

AGARD INDEX OF PUBLICATIONS (1971-1973)

## TYPICAL PERSONAL AUTHOR INDEX LISTING



Listings in this index are arranged alphabetically by personal author. The title of the document provides a brief description of the subject matter. The report number helps to indicate the type of document cited. The page number identifies the page in the abstract section (Part I) on which the citation appears while the NASA accession number denotes the number by which the citation is identified on the abstract page. Under each author's name, the accession numbers are arranged in ascending number order.

### A

- AARONS, J.**  
Satellite scintillations in the high altitude F layer irregularity region. p0128 N72 21138  
HF auroral backscatter and the scintillation boundary. p0130 N72 21150  
Total electron content and scintillation studies of the ionosphere. p0187 N73 22350  
[AGARD AG 166]  
Numerical models of total electron content over Europe and the Mediterranean and ionospheric scintillation components. p0187 N74 14584  
[AGARD AG 168A]  
Multi-station observations. December 1971 - March 1972. p0187 N74 14587  
The effect of the August 1972 magnetic storms on scintillation. p0187 N74 14588
- ABBOTT, F. T.**  
On the use of free jet for increasing Reynolds number in wind tunnel testing of three dimensional aircraft models at subcritical and supercritical Mach numbers. p0315 N72 11879  
[NASA TM X 67417]
- ABEL, M.**  
Observations on a 12 GHz scatter line over a 210 km path. p0118 N71 23458  
Some observations of scattering from rain at a 12 GHz trans horizon link. p0141 N73 26133
- ABEL, S. M.**  
Optokinetic nystagmus: its value in the diagnosis of certain vestibular lesions. p0169 N74 20742
- ACKERMAN, G. H.**  
Cooling of advanced engines by endothermic reactions of hydrocarbon fuels. p0251 N72 11672
- ACUS, R. W. JR.**  
Self contained guidance technology. p0227 N72 23693  
Application of inertial technology to A-7 missiles. p0227 N72 27691
- ADDIS, I.**  
The electroluminescent lighting research program. p0226 N72 22644
- ADDY, A. L.**  
The analysis of supersonic jet systems. p0193 N73 17251

- A study of flow separation in the base region and its effects during powered flight. p0020 N74 14724
- ADEY, A. W.**  
Theory and field tests of a microwave radiometer for determining sea ice thickness. p0121 N72 16089
- ADOLPH, C. F.**  
Criteria trends obtained from analysis of current aircraft. p0039 N72 32025
- ADSHED, H. G.**  
Optimizing automatic tracking of multilayer boards. p0168 N74 13935
- AGY, V.**  
A model for the study and prediction of aural effects on HF radar. p0130 N72 21153
- AHA, R. S.**  
Establishing requirements for artificial intelligence in the airborne and space environments. p0151 N72 11175
- AMARRAH, R. C.**  
Low altitude high speed flight experience. p0029 N71 23471  
Flight simulation: A significant aid in aircraft design. p0045 N73 17001
- AHRENSDOERF, K.**  
Fatigue design practice. p0360 N74 19654
- AIKEN, W. S.**  
NASA proposed STOL technology program. p0035 N73 27009
- AKAMATSU, Y.**  
Representations of a wing in the lifting line: application of the interaction calculation of two wings in tandem. p0008 N71 29336
- AKGUEL, M.**  
Application of discriminate function technique to random search. p0196 N74 15603
- ALBRECHT, C. O.**  
Factors in the design and fabrication of powered dynamic wind tunnel STOL wind tunnel models applicable to. p0018 N73 22956
- ALBRECHT, H. J.**  
The identification of military utilization of frequency bands above 10 GHz. p0149 N74 13498  
[AGARD AG 421]  
The identification of military utilization of frequency bands above 10 GHz. p0149 N74 13499  
[AGARD AG 42 REV]  
Tropospheric radio wave propagation: part I. Conference proceedings. p0114 N71 21469  
[AGARD CP 70 71 PT 1]  
Tropospheric path parameters with multiple access systems in space communications. p0115 N71 21421  
Daily and hourly forecast of tropospheric propagation parameters. p0120 N71 23470  
Propagation effects on monitoring atmospheric fine structure using side scatter on appropriate frequencies. p0122 N72 16097  
Propagation systems with tactical satellite communications. p0132 N73 10201  
System considerations in tactical satellite communications. p0132 N73 10202
- ALCOCK, R. N.**  
Design and evaluation of a helicopter guidance aid. p0034 N72 11936
- ALDRIDGE, S. E.**  
Experimental results of high bypass ratio turbulent and wing aerodynamic interference. p0004 N71 19176
- ALES, P.**  
High energy temperature turbine on turbine fires and gas turbines. p0257 N71 17373  
Cycles of a gas turbine. p0262 N71 26954
- ALEXANDER, J. C.**  
Proposed navigation for military helicopters: Applications and operational requirements. p0034 N72 11938
- ALEXANDER, P.**  
Signal distortion and intermodulation with tropospheric scatter. p0119 N71 23461
- ALLEGRE, J.**  
Drag of flying bodies for pilots at high altitude. p0021 N74 14731
- ALLEN, C. L.**  
Physical fitness as part of crew training. p0091 N71 22305  
Aerobically safe survey: Canadian Forces personnel. p0092 N71 22311
- ALLEN, O.**  
Early thoughts on compound stress. p0104 N73 19144
- ALLEN, J. E.**  
Altitude for aerobics. p0161 N74 16939
- ALLEN, M. F.**  
The oxygen and hypoxemia in flying and hypoxia subjects of the USAF SAM and low altitude flight study. p0087 N74 13803
- ALLKOFER, O. C.**  
Present knowledge of cosmic rays. p0075 N72 26046
- ALLNUT, M. F.**  
The psychologist's role in aircraft accident investigation. p0107 N74 18603
- ALLNUTT, M. F.**  
The novel task as a measure of performance under environmental stress. p0069 N71 20363  
Emotional and cardiovascular stresses of crew flight in Effect of beta receptor blockade on heart rate response. p0105 N73 19149
- ALLUM, J. H. J.**  
Automated nystagmus analysis. p0110 N74 20751
- ALTMAN, F. J.**  
Precipitation models from radar and rainfall data. p0146 N74 13854
- ALSHULER, E. E.**  
Polarization of atmospheric wave lengths. p0114 N71 21415
- AMACKER, J. Z.**  
Area navigation: Cost versus operational benefits. p0233 N73 23697
- AMBLER, R. K.**  
Assessment of effects of vestibular deafferentation stress for purposes of crew selection. p0079 N73 21696
- ANASTASIADIS, K.**  
Electric and space activities in Greece. p0395 N74 21612
- ANDERSON, C. A.**  
Statistical characteristics of the F-111 aircraft. p0043 N73 15013
- ANDERSON, D.**  
Gyro characteristics for rapid gyrocompassing. p0231 N73 20709
- ANDERSON, E. C.**  
Effects of strong axial pressure gradients on turbulent boundary layer flows. p0176 N72 20231  
[NASA CR 125903]
- ANDERSON, R. O.**  
Theoretical pilot rating predictions. p0040 N72 32036
- ANDERSON, S. B.**  
Review of STOL and STOL aircraft. p0038 N72 32021  
report 40B  
Considerations for stability and control of V-STOL aircraft: A review of AGARD report 577. p0044 N73 16934
- ANDERSON, W. E.**  
Engineering utility and significance of stress corrosion cracking data. p0285 N72 21901  
Corrosion fatigue: or how to replace the full scale fatigue test. p0295 N73 29929  
A rational analytic theory of fatigue: revised. p0295 N73 29931
- ANDES, R. A.**  
Automatic approach and hover: Coupler for HM-53 helicopters. p0032 N72 11926
- ANDRENUCCI, M.**  
Theoretical models for plasma motion in pulsed coaxial hydromagnetic guns. p0066 N73 19057
- ANDREWS, L. J.**  
Real time programs for aerospace vehicles. p0155 N72 21215
- ANDREWS, S. J.**  
The nature and use of the rules for judging the acceptability of the flying qualities of fixed wing aircraft. p0038 N72 32019
- ANGIBOUST, R.**  
Is laboratory experimentation useful for studying human adaptation to uninhabitable sensory environments? p0059 N71 20364  
Modifications of performance under certain medications: Proposed measuring method. p0080 N73 21110
- ANSON, A.**  
The use of aerial photography in the reconnaissance of soils and rocks. p0124 N72 16110
- ANTONATOS, P. P.**  
Inter-airplane interference and integration. p0017 N72 27018  
Assessment of the influence of inlet and altitudinal noise performance on total aircraft drag. p0021 N74 14726
- AOYAMA, K.**  
Bodies of revolution at transonic speeds: The estimation of Reynolds number effects. p0012 N72 11864
- APEL, G.**  
Syringomyelia and flying fitness. p0081 N73 23061
- APPLETON, B.**  
Predictive visual performance in a static environment. p0078 N73 19074
- APPLETON, J. P.**  
Sociological, health and environmental implications. p0079 N74 14230
- ARCHER, D. D.**  
Stability and control: 147 flight testing. p0034 N72 20917

AUTHOR

# ARCIDIACONO, P. J.

- ARCIDIACONO, P. J.**  
Helicopter rotor loads predictions p0056 N74 10912
- ARQUELLO, R. J.**  
Differential pulse code modulation transmission of sampled aerial imagery p0131 N73 10190
- ARMSTRONG, F. W.**  
Some recent research on supersonic intakes at NGTE p0004 N71 19372
- ARMSTRONG, S. M.**  
US Air Force Aerospace Research Prior. School p0036 N72 20994
- ARNOLD, J. I.**  
The effect of active controls on structural responses p0007 N71 23212
- ARNOLD, J.**  
IMAG 2: Electronic circuit simulations p0167 N74 13927
- ASCHOFF, J. C.**  
Computer electroencephalography in evaluating the influence of psycho pharmacological drugs on vigilance p0109 N74 20749
- ASCOUGH, J. C.**  
Measurement full scale of propelling nozzle performance in an altitude test facility p0263 N72 16691
- ASHFORTH, R. M.**  
The operational proving of automatic flight control systems in the approach and landing phase p002P N71 23414
- ASHLEY, H.**  
Optimization under aeroelastic constraint [NASA CR 117198] p0294 N71 20139  
Optimization techniques in aircraft configuration design p0285 N71 20140  
Some considerations relative to the prediction of unsteady air loads on interfering surfaces p0007 N71 29334
- ASHWOOD, P. F.**  
Free jet tests of a full scale supersonic intake engine combination p0265 N72 16704
- ASTON, I. R.**  
The MIRA vehicle impact test facility p0103 N72 19154
- ATHERTON, D. L.**  
Lightweight superconductor magnet for airborne MHD generators p0064 N73 19538
- ATKINSON, P. G. JR.**  
Technical evaluation report on the AGARD Propulsion and Energetics Panel 34th Meeting 18th colloquium on Reactions Between Gases and Solids [AGARD AR 32 71] p0261 N71 19177
- ATTER, D.**  
Design and evaluation of a helicopter guidance aid p0034 N72 11936
- AUFFERT, R.**  
Ejection acceleration: Physiological effects tolerance p0102 N72 19146  
Radiological study of spinal injuries to pilots undergoing sudden ejection p0102 N72 19148  
Physiological modifications during operational flights of long duration p0106 N73 19152  
Modifications of performance under certain medications: Proposed measuring method p0080 N73 21110  
Effect of altitude on cerebral blood flow patterns in the smoker and non smoker p0082 N73 21125  
Aerobic fitness for flying duties after vertebral fractures and spinal surgery p0086 N74 13194
- AULEHLA, F.**  
Nozzle-airframe interference and integration p0037 N72 27020
- AUTCHAUD, O.**  
Flight safety with automatic control: requirements and implementation p0031 N72 11919

## B

- BAALS, D. D.**  
Reynolds number requirements for valid testing at transonic speeds [NASA TM X 57412] p0012 N72 11859  
A facility concept for high Reynolds number testing at transonic speeds [NASA TM X 57418] p0015 N72 11880
- BACK, K. C.**  
Special aspects of aviation occupational medicine: Cardiovascular and nervous system effects of biocontrol on man p0027 N73 17165  
Environmental toxicological impact of aircraft operations p0222 N74 14306
- BAQOT, R.**  
Velocity distribution at a supersonic compressor inlet p0067 N72 16713
- BAHR, D. W.**  
Technology for the reduction of aircraft fuel and engine exhaust emissions p0221 N74 14369
- BAHRET, W. F.**  
Full scale measurement of RCS p0144 N73 17358  
The use of RCS data p0145 N74 17355
- BAHREL, O.**  
Measurement of wing shock waves p0222 N74 14378
- BAILEY, C. C.**  
Characterization of the supersonic start of a supersonic turbine response measurement p0119 N73 21466

- BAILEY, R. W.**  
Aircraft color vision requirements p0078 N73 19073  
Air to ground target acquisition p0303 N73 19989
- BAILY, D. L.**  
Pollution control of airport engine test facilities p0219 N74 14285
- BAINBRIDGE, A.**  
Electricity generation and distribution systems for future supersonic aircraft p0066 N73 19054
- BAIRD, E. F.**  
Recent developments in flight flutter testing in the United States: Supplement to the Manual on Aeroelasticity, volume 4, chapter 10 [AGARD R 596] p0046 N73 18030
- BAKER, B. E.**  
Operational considerations and systems reliability p0190 N71 36788
- BAKER, C. M.**  
Av BA Harrier concept and operational performance: US Marine Corps p0054 N73 27005
- BALACHANDRAN, N. K.**  
Acoustic gravity waves in the neutral atmosphere and the ionosphere [CONTRIB 1799] p0135 N73 14146
- BALDES, E. J.**  
Symposium on Linear Acceleration of Impact Type Introductory remarks p0098 N72 19121
- BALDRIGHI, G.**  
Human eye movements during various forms of linear acceleration and weightlessness p0109 N74 20747
- BALDRIGHI, G.**  
Responses of bird fish to gravitational changes as achieved in parabolic flight p0075 N73 21101
- BALLA, A.**  
Behavior of some serum enzyme activities in man after crash accidents causing massive injuries p0101 N74 19138
- BALLHAUS, W. F.**  
The effect of platform shape on the transonic flow past rotor tips p0051 N73 21048
- BALMER, R. J.**  
The Harrier: Some aspects of V STO stability and control flight testing p0035 N72 20980
- BALMFORD, D. E. H.**  
Ground and flight test experience with the Westland Scout hingeless rotor helicopter p0047 N73 21017
- BALSA, T. F.**  
The prediction of axial compressor performance with emphasis on the effect of annulus wall boundary layers p0270 N73 19812
- BAMBERGER, E. N.**  
Lubricant and fuel interactions in advanced aircraft gas turbines [NASA CR 122842] p0254 N72 17694
- BANCILERO, N.**  
Effects of positive G<sub>y</sub> accelerations on blood oxygen saturation and pleural pressure: relationships in dogs breathing first air then liquid fluorocarbons in a whole body water immersion respirator p0068 N71 20358  
[NASA CR 117199] p0068 N71 20358
- BANCROFT, R. W.**  
Aeromedical evaluation of the phased titration concept for oxygen breathing systems p0083 N73 23055
- BANDE, J.**  
Longitudinal study of composite values for navigator personnel of the Breguet Air Force p0094 N71 22321  
Analytical study of the ranges of medical unfitness of flying personnel in the Belgian Air Force p0095 N72 14093
- BANNINK, W. J.**  
The anti drag characteristics of delta wing configurations with subsonic leading edges using slender body theory p0032 N71 19359
- BARBER, D. L. A.**  
Packet Switching network p0158 N72 22171
- BARBER, M. O.**  
Color video stigmagraphy: its value in the diagnosis of certain vestibular lesions p0109 N74 20742
- BARDOLLE, J.**  
Relations between meteorological data and test stage of the real time and formation of oxide layers p0201 N73 23603
- BARNES, A. G.**  
Observations of auroral arcs p0121 N71 16062  
Summary paper for 14th Meeting, Spring 1970, NASA Research Center p0344 N73 16992  
NASA S-155 testing and handling of instruments p0059 N74 17341
- BARNES, G. R.**  
A model for the prediction of the system response to irregular and variable aerodynamic loads p0130 N74 20762
- BARNES, G. W.**  
Simple mathematical system analysis of a satellite p0144 N73 19014
- BARNES, J. A.**  
What is a hypersonic engine p0223 N72 20624
- BARNETT, C.**  
A review of the present and proposed defense systems for the defense of the United States of America p0159 N74 16926
- JARRATT, E. S.**  
The influence of a cavity on the flow past a flat plate p0069 N71 20361

# PERSONAL AUTHOR INDEX

- BARREAU, O.**  
High frequency backscatter observations at medium latitudes of high latitude field aligned irregularities p0130 N72 21149
- BARRERE, M.**  
Modelization of turbomachine combustion for pollution studies p0220 N74 14298
- BARRETT, R.**  
Remote transmission and automated retrieval techniques p0169 N74 19633
- BARROIS, W.**  
A short survey on possibilities of fatigue life assessment of aircraft structures based on random or programmed fatigue tests p0291 N73 16897  
Designers' need for general information from analysis of fatigue test results and service behavior p0061 N74 19680
- BARTH, R.**  
The hingeless rotor: A concept to increase mission effectiveness at reduced costs p0305 N74 21616
- BARTKOWIAK, A.**  
Fire hazard evaluation of thickened aircraft fuel p0253 N72 11689
- BASSENBERG, H.**  
Ranging transponders for interplanetary space probes p0194 N72 19510
- BASSETT, R. W.**  
Flow distortion and performance measurements on a 12 inch fan in wing model for a range of forward speeds and angle of attack settings p0265 N72 17102
- BASSINET, E.**  
Cooling of turbine distribution blades through a past effect p0260 N71 17397
- BASTIDON, J.**  
Establishing safety margins for the take off and approach of the Breguet 941 p0028 N71 23420
- BASTIEN, J.**  
Current aspects of cochlear function: applied to flying personnel p0086 N74 13800
- BATES, H. F.**  
Sweep frequency backscatter radar as detectors of high latitude ionospheric phenomena p0129 N72 21147
- BATHIAS, C.**  
Influence of microstructure on the growth of fatigue cracks p0204 N74 23112
- BATT, J. R.**  
Minimum weight design of surface effect vehicles using the sieve search technique p0297 N74 15610
- BATTESTI, J.**  
Propagation by atmospheric heterogeneities and forecasts of attenuation p0120 N71 23468  
Experimental method of measuring propagation attenuation of radio p0142 N73 26138
- BATTEZZATO, L.**  
Potential use of composite materials for gas turbine structures p0213 N73 27495
- BATTIN, R. H.**  
Altitude control of the Apollo spacecraft p0278 N72 12870
- BAUERFEIND, K.**  
Extraction of auxiliary power from a breathing propulsion system p0065 N73 19050
- BAKENDALE, S. B.**  
Some mechanical design problems of turbine blades and discs p0261 N71 17401
- BAYLEY, F. J.**  
Transpiration cooled turbines p0258 N71 17383
- BEAN, B. R.**  
Worldwide barometeric solidification index and climatology effects p0114 N71 21412
- BEARMAN, P. W.**  
Some measurements of the distribution of turbulent air approaching a two dimensional body p0118 N72 20307
- BEASLEY, J. A.**  
Some examples of the application of methods for the prediction of boundary layer transition on sheared wings p0183 N73 25281
- BEAUMONT, L. C.**  
An evolving operational computer aided design system p0167 N74 13929
- BECK, A.**  
The use of computer spatial atmospheric models in airwaves: Evaluation of the techniques p0085 N74 13795
- BECKER, B.**  
A review of the state of the design of the turbo-propeller engine cycle of the turboprop engine at high flight Mach numbers p0267 N72 16151
- BECKER, J.**  
Infrared imaging systems: steady state and flow comparisons between theory and experiment [AGARD R 614] p0212 N74 18651
- BECKER, K. H.**  
Photo catalytic air conditioning in aircraft and high speed jets p0219 N74 14277
- BECKER, K. O.**  
Method of aircraft propagation of electromagnetic waves in an inhomogeneous atmosphere above rough ground p0117 N73 21432
- BECKER, P. W.**  
Pattern recognition and display for pilot's information p0145 N72 17204  
Computer aided design for navigation p0145 N72 17204  
Computer aided design for navigation p0145 N72 17204

# PERSONAL AUTHOR INDEX

# BOWLING, H. T.

- BECKER, W.**  
Computer electronystagmography in evaluating the influence of psycho-pharmacological drugs on vigilance p0109 N74 20749
- BECKETT, R. G.**  
Fuel related problems in aircraft fuel systems p0252 N72 11677
- BEDAGUE, P.**  
Synthesis and properties of esters of tetramethyl 2,2,7,7 octane diol 1,8 p0254 N72 11696
- BEER, B.**  
Automatic speaker recognition systems p0151 N72 11179
- BEISCHER, D. E.**  
Magnetic fields and man: Where do we stand today? [NASA CR 127049] p0076 N72 26055
- BELL, P. D.**  
Fatigue and fracture considerations for tactical aircraft p0060 N74 19656
- BELLMAN, D. R.**  
A comparison of some aerodynamic drag factors as determined in full scale flight with wind tunnel and theoretical results [NASA TM X 67413] p0013 N72 11869  
A flight investigation of steady state and dynamic pressure phenomena in the air inlets of supersonic aircraft [NASA TM X 67495] p0266 N72 16709  
Techniques for the evaluation of air breathing propulsion systems in full scale flight [NASA TM X 68305] p0035 N72 20983
- BELLO, P. A.**  
Signal distortion and intermodulation with tropospheric scatter p0119 N71 23463
- BELLOT, J.**  
Investigation of an accelerated stress corrosion cracking method p0288 N72 21924
- BENDIXEN, R. L.**  
A report of aviator grounding and aviator salvage in high performance fighter aircraft p0095 N72 14094
- BENEDETTO, S.**  
On the efficient bandwidth utilization in digital transmission p0131 N73 10193
- BENNETT, R. L.**  
Rotor system design and evaluation using a general purpose helicopter flight simulation program p0056 N74 10913
- BENNETT, W. A.**  
The effect of free stream turbulence level on turbulent boundary layer behavior p0268 N73 19799
- BENSON, A. J.**  
The dissemination incident part 1 [AGARD CP 95 PT 1] p0071 N72 25031  
Spatial disorientation and the break off phenomenon p0072 N72 25042  
Spatial disorientation in flight: A handbook for aircrew [AGARD AG 170] p0084 N74 12748  
Use of nystagmography in the study of aircrew with spatial disorientation p0108 N74 20736  
A model for the prediction of the nystagmic response to angular and linear acceleration stimuli p0110 N74 20752
- BENTLEY, C. R.**  
Electromagnetic sounding of ice thickness p0123 N72 16099
- BERFIELD, R. G.**  
Integrated inertial Doppler total computer guidance and control p0157 N72 21224
- BERGMAN, D.**  
An aerodynamic drag study of jet engine nozzles p0266 N72 16707
- BERGT, W.**  
Exhaust emission measurements on the GE T64-7 turbo-prop engine p0219 N74 14286
- BERKE, L.**  
Application of optimality criteria approaches to automated design of large practical structures p0296 N74 15599
- BERNER, S.**  
Reliability and safety of operating mechanical helicopter gears p0047 N73 21012
- BERNHARDT, R.**  
Problems of data recording and data interchange p0159 N73 24207
- BERNHART, W. J.**  
Computers for the guidance and control of tactical aircraft p0151 N72 21227
- BERNSTAT, R. K.**  
Post workload p0240 N72 32035
- BERROIR, R.**  
Featureless flight methods p0283 N73 23895
- BERRY, J. B.**  
Examples of airborne store interferences p0005 N71 13380
- BERTHE, C.**  
The theory of atmospheric acoustic propagation p0136 N73 14142
- BERTHOUX, J. A.**  
Tactical flight of helicopter and representation of the concept p0146 N73 21600
- BERTONE, C. M.**  
Fixed and adaptive algorithms for pattern recognition: Problem in theory and application p0152 N72 11385
- BERTRAND, J. M.**  
Technological aspects of turbine blade cooling by air film p0261 N73 17404
- BETHELL, J. P.**  
Establishing small information centres in industry p0158 N73 24203
- BETHOUX, J. P.**  
Solar energy and seasonal thermocline p0241 N73 33623
- BETTS, J. A.**  
Generation of intermodulation interference due to non-linear effects in the near field regions of multiple transmission communication system p0134 N73 19212
- BETZ, W.**  
Eutectic alloys with unidirectional solidification: Study on their use for turbine blades p0213 N73 27494
- BEUN, M.**  
A naive method for machine recognition of hand written numerals p0153 N72 11193
- BEYER, R.**  
A limited study of the trade off between luminance and color coding in electronic aircraft displays p0223 N72 22623  
V-STOL displays for approach and landing p0224 N72 22632
- BNATELEY, I. C.**  
A simplified mathematical model for the analysis of multielement airfoil rear stall p0042 N73 15009
- BIDDLE, J. R.**  
Evaluation of film cooling performance on gas turbine surfaces p0260 N71 17395
- BIEFER, G. J.**  
Screening tests of susceptibility to stress corrosion cracking p0287 N72 21911
- BIGEON, P. J.**  
The less flight methods p0280 N73 23895
- BIGGS, A. W.**  
Telecommunications aspects on frequencies between 10 and 100 GHz [AGARD CP 107] p0140 N73 26127
- BILLINGS, C. E.**  
Ethyl alcohol as a tip for performance: Military implications of flight studies p0093 N73 21113
- BINBAUM, M.**  
Aircraft navigation systems testing with a high precision reference p0237 N74 14353
- BISLOD, P. L.**  
Stability and control tests on a slender wing research aircraft p0036 N72 20990
- BISHOP, G.**  
Padar sea clutter p0145 N74 11962
- BISHOP, G. J.**  
Measurement of atmospheric attenuation at the frequencies of 15, 19, and 34 GHz p0149 N74 13870
- BITTERLICH, W.**  
Amplified wall boundary layers in sea flow turbomachines p0270 N73 19874
- BLACK, A. W.**  
Depression in aircrew p0088 N74 18784
- BLACK, F. D.**  
Normal limits for the sequential bithermal binocular caloric test p0109 N74 20746
- BLACKBURN, L. H.**  
Disorienting effects of aircraft catapult launchings p0077 N72 25037
- BLACKERBY, W. T.**  
A survey of drag prediction techniques applicable to subsonic and transonic aircraft design p0019 N74 14711
- BLACKMER, R. H. JR.**  
Satellite viewed forward view as a descriptor of radar propagation conditions p0114 N71 21474
- BLACKWELDER, R. F.**  
Intermittent structures in turbulent boundary layers p0175 N72 20217
- BLAHA, B. J.**  
Flight and wind tunnel investigations of installation effects on underwing supersonic cruise exhaust nozzles at transonic speeds [NASA TM X 66887] p0003 N71 19366
- BLANC, P.**  
Current aspects of nonlinear function applied to flying personnel p0096 N74 11810  
A proposed habituation labyrinth: Presentation of several results with the P.N.T. p0108 N74 20737
- BLANCHARD, C. H.**  
Automatic message switching and data traffic handling in a military communications network p0133 N73 13206
- BLAND, S. R.**  
Comments on NASA Langley research on transonic unsteady aerodynamics [NASA TM X 69997] p0023 N74 18652
- BLANQUART, P.**  
Techniques of analyzing acceleration p0190 N71 36786
- BLANDELL, W. E.**  
Signal analysis and classification by interactive computer graphics p0154 N72 11201
- BLAUVELT, D. H.**  
Fast isolation in digital guidance and control computer p0156 N72 21220
- BLAZOWSKI, W. S.**  
Aircraft gas turbine engine start limitations oriented toward maximum efficiency and engine performance p0227 N74 14245
- BLOCH, P.**  
Expansion of the French flight test center in all weather helicopter landing p0034 N72 11933
- BLOMQUIST, A.**  
Beyond the horizon: propagation over sea at 170 and 5000 MHz p0116 N71 21429  
Variations in diffraction loss due to tropospheric effects at frequencies between 180 MHz and 10 GHz in hilly terrain p0146 N74 13852
- BLOOMFIELD, J. R.**  
Calculation and simulation of the effects of two complex search situations p0302 N73 19963  
Peripheral acuity with complex stimuli at two viewing distances p0303 N73 19965
- BUNDON, G.**  
Behaviour of some serum enzyme activities in man after crash accidents causing massive injuries p0101 N72 19138  
In flight psychic load in student pilots: evaluated by means of Vanil Mandelic Acid (VMA) changes in urinary excretion p0089 N74 18790
- BOBBETT, E. M.**  
Rate of closure as a performance as a performance monitoring parameter p0226 N72 22643
- BODINE, E. G.**  
Armor materials for life support p0102 N72 19143
- BOEHM, G.**  
Subsonic unsteady airloads on multiple lifting surfaces p0008 N71 29339
- BOESSO, S.**  
A general purpose computer for spaceborne applications p0280 N73 23854
- BOHN, P.**  
Research work and costs: the role of data processing p0306 N74 21617
- BOISSEAU, J. P.**  
Calculation of aerodynamic interactions between lifting elements of an airplane in supersonic, stationary or nonstationary flow p0002 N71 19362
- BOITHIAS, L.**  
Propagation by atmospheric heterogeneities and forecast of attenuation p0120 N71 23468  
Experimental method of measuring propagation attenuation of rain p0142 N73 26138  
Effect of terrain screening on the different mechanisms of propagation p0146 N74 13850
- BOLLANI, G.**  
A contribution to stress corrosion testing of aluminum alloys p0288 N72 21918
- BOMONT, G.**  
Utilization and suppleness of high numerical data storage in telecommunications p0131 N73 10194
- BONFIELD, W.**  
Micro fastcity in materials for inertial navigation systems p0228 N73 20692
- BOORER, N. W.**  
Military aspects of civil V-STOL aircraft p0055 N73 27011
- BORGES, L. R.**  
Interest of nystagmography in flying navigation personnel p0108 N74 20738
- BORE, C. L.**  
On the possibility of deducing high Reynolds number characteristics using boundary layer section p0014 N72 11875  
Post stall aerodynamics of the Harrier GR1 p0043 N73 15014
- BORGEAUD, C.**  
Small tactical missiles for 1980 and beyond: Volume 1: Summary [AGARD AR 57 VOL 1] p0306 N74 73503  
Small tactical missiles for 1980 and beyond: Volume 1: executive summary [AGARD AR 57 VOL 1] p0307 N74 73504  
Small tactical missiles for 1980 and beyond: Volume 2 [AGARD AR 57 VOL 2] p0307 N74 73505
- BORGHI, R.**  
Theoretical study of the radial evolution of rotating products in turbine exhausts p0220 N74 14294
- BORLAND, R. C.**  
Use of hypnosis by aircrew: Adaptive tracking as a technique for the evaluation of performance deterioration related to the flight task p0080 N72 21109
- BORLAND, R. G.**  
Laser safety: Some considerations in the design of a code of practice p0076 N72 26057
- BOS, J.**  
Measurements of turbulent turbulent boundary layer flow in a channel radial flow p0252 N72 15681
- BOSCO, A.**  
Aerodynamics of helicopter components other than rotor p0053 N73 21052
- BOTTERI, B. P.**  
Flammability properties of jet fuels and their consequences on explosion suppression p0252 N72 15681
- BOURNE, G. H.**  
Bridging monkeys for biomechanical research p0083 N73 23063
- BOWITCH, G. N.**  
Intelligence people would have test setting as [NASA TM X 67494] p0263 N72 15692  
Technical evaluation of the Progress and the Progress Page 18th Meeting on the 1st and 2nd AeroSpace Engines [NASA TM X 67741] p0267 N72 21819
- BOWLING, H. T.**  
Improving the predictive ability of systems for turbine engine airframe cooling: cost effectiveness p0226 N72 22663



# BOWMAN, G. G.

- BOWMAN, G. G.**  
Atmospheric pressure waves at Brisbane and their association with certain ionospheric and solar events. p0136 N73 14146
- BOYD, D. D.**  
The dynamic biomechanical nature of spinal fractures and angular facet derangement. [AMRL TR 71 17] p0101 N72 19139
- BOYD, W. K.**  
The use of slow strain rate experiments in evaluating resistance to environmental cracking. p0289 N72 21927
- BRACCO, A.**  
Elastic constant evaluation of a reinforced plastic material. p0207 N72 12497
- BRADLEY, P. A.**  
Polarization effects on sky wave paths at high latitudes. p0129 N72 21145
- BRADLEY, R. G.**  
A simplified mathematical model for the analysis of multilevel airfoils near stall. p0042 N73 15009
- BRAOSHAW, P.**  
Variations on a theme of Prandtl. p0175 N72 23174  
Effects of streamline curvature on turbulent flow. [AGARD AG 169] p0184 N74 12442
- BRÄKMAN, G.**  
Comparisons between some high Reynolds number turbulent boundary layer experiments at Mach 4 and various recent calculation procedures. p0177 N72 20789
- BRANDS, H. J.**  
Directionally solidified eutectics in gas turbine design. p0212 N73 27493
- BRANDT, T.**  
Self motion sensation, pseudo-cortex effects and motion sickness induced by catokinetic stimuli. p0109 N74 20744
- BRANHAM, L. B.**  
Incidence cost and factor analysis of pilot error accidents in US Army aviation. p0107 N74 18804
- BRANHAM, L. A.**  
Correlation bandwidth measurements over troposcatter paths. p0119 N71 23465
- BRASSEUR, G.**  
Chemical kinetic in the stratosphere. p0218 N74 14279
- BRATTENG, O.**  
High latitude satellite communication. p0128 N72 21140
- BRAUDAWAY, G. V.**  
Aerospace computer word length considerations. p0156 N72 21217
- BRAVTON, D. B.**  
Laser lithography. p0200 N72 23303
- BREANT, P.**  
Utilization and suppleness of high numerical difference support in telecommunication. p0131 N73 10194
- BRENNAN, D. M.**  
Colour vision requirements in current operational roles. p0077 N73 19072
- BREUHAUS, W. O.**  
The selection of tasks and subjects of flight simulation experiments. p0172 N71 16067
- BRIAPLON, R.**  
Motorist point of view on the effects of low burning rates on pollution. p0221 N74 14303
- BRITTON, C. A.**  
The influence of environmental factors in aircraft carrier landings and accidents. p0370 N71 20369
- BRIDGE, C. S.**  
Airborne area navigation equipment. p0233 N73 23698
- BRIDGEWATER, A. W.**  
Weather radar image processing. p0151 N72 11181
- BRIDGEWATER, J.**  
Theoretical and experimental investigations of wind-turbine configurations at low supersonic speeds. p0092 N71 19358
- BRIGGS, T. S.**  
A navigation computer and display unit for Harrier. p0224 N72 22633
- BRINKLEY, J. W.**  
Restraint design: laboratory test and evaluation of operational effectiveness. p0104 N72 19157
- BRISTOW, D. R.**  
Evaluation of the prediction of airplane noise interference by linear theory. p0205 N71 19381
- BROCHE, P.**  
Nonlinear propagation and ionospheric coupling of atmospheric waves generated by a nuclear explosion. p0140 N73 14168
- BROOKE, J. F.**  
Impact of technology on cost reduction. p0305 N74 21618
- BROOKS, W. A. JR.**  
Application of composites to the selection and design of metallic aerospace structures. p0211 N73 27485
- BROSSEAU, P.**  
Surface pressure fluctuations from jet impingement on an inclined flat plate. p0292 N72 25309
- BROTHERHOOD, P.**  
Some flight experiments in the KH-51N helicopter. p0247 N73 21015  
The derivation and verification of a new method for the analysis of flow phenomena in airfoil research. p0051 N73 21047
- BROWER, R.**  
Factors affecting the accuracy of sea surface temperature measurements from ITOS SR data. p0124 N72 16107

- BROWN, D. D.**  
Elevated blood pressure in aircrew. p0085 N74 13787
- BROWN, G.**  
The effect of density difference on the turbulent mixing layer. p0178 N72 20295
- BROWN, G. V.**  
A numerical analysis of a single bladed hovering rotor and a comparison with experimental data. p0049 N73 21035
- BROWN, K. R.**  
Gyro characteristics for rapid gyrocompassing. p0231 N73 20709
- BROWN, M. B.**  
The effect of complex backgrounds on acquisition performance. p0303 N73 19964
- BROWN, R. D.**  
Analysis of the vestibulo-ocular counterroll reflex in primates. [AMRL TR 71 59] p0072 N72 25040
- BROWN, T. J.**  
Dynamic loading of aircraft surfaces due to jet exhaust impingement. p0292 N73 23908
- BROWN, W. E.**  
Measurement of atmospheric attenuation at the frequencies of 15, 19 and 34 GHz. p0149 N74 13870
- BRUENING, G. F.**  
Simulation: An introduction and survey. p0171 N71 16051
- BRUNETAUD, M.**  
Materials currently employed in high temperature components of the aircraft gas turbine. p0201 N73 23630
- BRUNTAUD, R.**  
Materials development for high temperature turbines. p0259 N71 17392
- BRUTON, D. M.**  
Pollution levels at London Heathrow Airport and methods for reducing them. p0218 N74 14284
- BUDINGER, T. F.**  
Visual phenomena induced by cosmic rays and accelerated particles. [NASA TM X 68460] p0075 N72 26051
- BUECHL, K.**  
Laser: A light source for high speed photography. p0207 N72 25524
- BUECKER, H.**  
The BIOSTACK experiment on Apollo 16. p0083 N73 23062
- BULLARD, J. B.**  
Some mechanical design problems of turbine blades and disks. p0261 N71 17401
- BURATTI, A.**  
The SIRIO altitude measurement and control system. p0278 N72 12869
- BURATTI, M.**  
Preliminary results of mechanical and stress corrosion tests on plates of 7075 alloy produced by a new processing technique. p0289 N72 21931
- BURCHAM, F. W. JR.**  
A flight investigation of steady state and dynamic pressure phenomena in the vicinity of supersonic aircraft. [NASA TM X 67495] p0266 N72 16709  
Techniques for the evaluation of air breathing propulsion systems in full scale flight. [NASA TM X 68305] p0035 N72 20983
- BURCHARD, E.**  
Spatial orientation in flight: A handbook for aircrew. [AGARD AG 170] p0094 N74 12748
- BURGESS, R. K.**  
Development of the ABC coin. p0048 N73 21029
- BURMAN, K.**  
Introductory papers: The present state of information activities in Turkey and future trends. p0158 N72 24202
- BURKE, E. J.**  
A real world situation display for all weather landing. p0233 N72 23702
- BURNEL, S.**  
Theoretical and experimental research of take off drag deformation of local surface. p0043 N73 15001
- BURNETT, K. T.**  
The status of human perceptual characteristic data for electronic flight display design. p0223 N72 22622
- BURNHAM, J.**  
Weather as a factor in fatal accidents involving civil transport aircraft. p0030 N71 23411
- BURNS, B. R. A.**  
Design considerations for the satisfactory stability and control of military combat aeroplanes. p0044 N73 16996
- BURRIS, W. R.**  
Aerodynamic design and flight test of US Navy aircraft at high angles of attack. p0043 N73 15020
- BURROUGHS, K.**  
A real world situation display for all weather landing. p0233 N72 23702
- BURROWS, W. G.**  
A study of the effects of tropospheric air mass movements on the long range transmission of radio waves: the use of a laboratory model. p0118 N71 23456  
Radio Wave diffraction due to a mountain of variable shape. p0146 N74 13851
- BURSTEIN, S. Z.**  
Nonlinear time dependent problems in fluid dynamics. p0185 N73 22976
- BURWOOD SMITH, A.**  
Fibre strengthened reinforced plastic. p0253 N71 17390

- BUSHMAN, B. M.**  
A simplified space technology method for clinical aircrew measurement of functional respiratory values. [NASA TM X 60370] p0074 N72 25057
- BUSBOLINI, J. J.**  
High reliability design techniques applied to the lunar module. p0190 N71 36781  
Methods of specifying and controlling design reliability. p0190 N71 36783  
The benefits of a totally integrated reliability test program. p0190 N71 36787
- BUTKEWICZ, P. J.**  
On a flow separation and buffet onset during fighter aircraft maneuvering. p0043 N73 15017
- BUTLER, S. F. J.**  
Technical evaluation report on Fluid Dynamics Panel Specialists Meeting on Aerodynamic Drag. [AGARD AG 58] p0018 N74 10905  
Technical Evaluation report. p0019 N74 14710  
Aircraft drag prediction for project appraisal and performance estimation. p0019 N74 14716
- BUXBAUM, O.**  
Extreme value analysis and its application to vertical accelerations measured on transport airplanes of type C 130. p0030 N71 25080  
A relation between measured center of gravity vertical accelerations and the loads at the T tail of a military airplane. [AGARD AG 597] p0041 N73 13019  
A relation between measured center of gravity vertical accelerations and the loads at the T tail of a military airplane. [AGARD AG 597] p0041 N73 13019  
Methods of stress measurement analysis for fatigue life evaluation. p0294 N73 29926
- BYFORD, G. H.**  
Hybrid computing: A technique for the immediate analysis of physiological data. p0083 N73 23064

# C

- CALICE, J. F.**  
Feasibility of testing a large chord swept panel model to determine wing shock location at flight Reynolds number. [NASA TM X 67414] p0013 N72 11870  
Simulation of full scale flight aerodynamic characteristics by tests in existing transonic wind tunnels. p0014 N72 11873
- CAHN, C. R.**  
Spread spectrum applications and state of the art equipment. p0143 N73 23058
- CAIGER, B.**  
Review of several factors relevant to jet nozzles. p0029 N71 23424
- CAIDEN, L.**  
The Automated Technical Control (ATEC) system. p0133 N71 10207
- CALFEE, R. F.**  
Erbium laser propagation in a CO<sub>2</sub> atmosphere of the near infrared. p0124 N72 16108
- CALLY, G.**  
Activities of LRBA in the media domain. p0231 N73 20714  
Determination of nonlinear accelerometers by a method of differential tests. p0231 N73 20715
- CALVERT, G. S.**  
An experimental cooled radial turbine. p0259 N71 17381
- CAMBERALE, R.**  
A general purpose computer for spaceborne applications. p0280 N73 23804
- CAMBERLEIN, L.**  
Method of measuring the inertia qualities of a quasi-spherical robot. p0228 N73 20691
- CAPPE, M. J.**  
Practical problems in clinical vestibulography. I. Guidelines for safe sound equipment. p0108 N74 20734
- CAPRILI, M.**  
Theoretical models for plasma motion in closed toroidal hydromagnetic gases. p0066 N73 19057
- CAPRONI, C.**  
Dispersion of an electromagnetic wave traveling through a stratified medium on non-spherical scattering. p0140 N73 26123
- CARADONNA, F. X.**  
The effect of planform shape on the aerodynamic flow past airfoils. p0051 N73 21048
- CARBONARO, M.**  
Review of some problems related to the design and operation of low speed wind tunnels for VLSI testing. p0173 N73 26240
- CARLSON, D. N.**  
Functional design of Microwave Landing System (MLS) airborne equipment as influenced by ground equipment configuration and aircraft type. p0234 N71 23705
- CARLSON, J. W.**  
Comparison of French and United States flying qualities requirements. p0038 N72 12019  
Predicted airplane longitudinal effects on stability and controllability. p0045 N73 17006
- CARLSON, R. G.**  
Helicopter rotor blade predictions. p0046 N74 10912

COOK, F. H.

- |  |   |   |
|--|---|---|
| <b>CARLSON, R. M.</b><br>Integrated rotor/body loads prediction<br>p0057 N74 10918   | <b>CHAPPELOW, J. W.</b><br>The application of aircrew options on cockpit tasks and equipment to flight safety research<br>p0107 N74 18802 | <b>CLARK, W. G. JR.</b><br>An apparatus for stress corrosion testing with large precracked WOL specimens<br>p0287 N72 21914                                       |
| <b>CARMICHAEL, J. G.</b><br>Maneuver and buffet characteristics of lighter aircraft<br>p0043 N73 16019   | <b>CHARNAV, V.</b><br>Development of a turbulent boundary layer on a flat plate in an external turbulent flow<br>p0180 N72 20306          | <b>CLARKSON, B. L.</b><br>Inventory of acoustic fatigue test facilities in the NATO countries<br>p0172 N71 34253  |
| <b>CARMICHAEL, R. L.</b><br>Recent experience in using finite element methods for the solution of problems in aerodynamic interference<br>[NASA TM X-66884]<br>p0001 N71 19357   | <b>CHASE, R. C.</b><br>Ethylalcohol and pilot performance: Military implications of in-flight studies<br>p0081 N73 21113                  | <b>AGARD, H. 584 [1]</b><br>Estimates of the response of box-like structures to acoustic loading<br>p0293 N73 29915   |
| <b>CARNEL, J.</b><br>Application of film cooling to gas-turbine blades<br>p0260 N71 17394  | <b>CHASMAN, M. R.</b><br>Solid lubrication for aero-propulsion systems<br>p0255 N72 11700   | <b>CLAY, C. S.</b><br>Effect of beam width on acoustic signals scattered at a rough surface<br>p0123 N72 16102  |
| <b>CARPETIS, C.</b><br>Research on cryogenics and inductive energy storage at the DFVLR<br>p0084 N73 19042   | <b>CHASSIAN, C.</b><br>Fracture initiation and stress corrosion cracking of welded joints of alpha-titanium alloys<br>p0289 N72 21929     | <b>CLEMENT, J.</b><br>Selection of student pilot candidates of the Belgian Air Force by psychomotor tests<br>p0088 N74 18788                                      |
| <b>CARR, J. G.</b><br>The experimental evaluation of automated navigation systems<br>p0280 N73 23896   | <b>CHECROUX, A.</b><br>Digital filtering procedures for a line image<br>p0155 N72-11204   | <b>CLEMENT, W. F.</b><br>Systematic manual control display design<br>[NASA CR 126256]<br>p0223 N72 22627  |
| <b>CARRE, R.</b><br>Tracing of atherosclerosis during evaluation of flying personnel<br>p0093 N71 22318  | <b>CHEN, C.</b><br>Adaptive equalization without test transmissions<br>p0132 N73 10200  | <b>CLIFFORD, D. R.</b><br>Approach path control for reduced noise and improved traffic capacity<br>p0029 N71 23425  |
| <b>CARRIE, P.</b><br>Value of cardiac mechanograms in evaluating flying personnel<br>p0085 N74 13791   | <b>CHENEY, M. C. JR.</b><br>Rotor wakes: Key to performance prediction<br>p0049 N73 21032   | <b>CLIFFORD, J. M.</b><br>Use of hydraulic by a screw: Considerations of metabolism and excretion<br>p0081 N73 21118  |
| <b>CARTIER, D. I.</b><br>human exposure criteria to laser energy<br>p0084 N73 23067  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>CLOUGH, J. W.</b><br>Electromagnetic sounding of ice thickness<br>p0123 N72 16099  |
| <b>CARTER, E. C.</b><br>Experimental determination of inlet characteristics and inlet and airflow interference<br>p0037 N72 27019  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COCHETEUX, J.</b><br>Test methods and examples from the Propulsion Test Center<br>p0263 N72 16690  |
| <b>CARTER, E. S.</b><br>Impact of new structural concepts on system capabilities<br>p0048 N73 21021  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COCKS, F. H.</b><br>Measuring the degree of concurrent action between stress and corrosion in stress corrosion<br>p0286 N72 21908                              |
| <b>CARTER, W. V.</b><br>The transient performance of two-dimensional jet flap aerofoils at high Reynolds numbers<br>p0012 N71 1861   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COE, C. F.</b><br>Pressure fluctuation inputs and response of panels underlying attached and separated supersonic turbulent boundary layers<br>p0092 N73 29910 |
| <b>CASCI, C.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COFER, R. H.</b><br>Preprocessing for personal pattern recognition<br>p0151 N72 11192  |
| <b>CASKEY, P. E.</b><br>Effects of positive G acceleration on blood oxygen saturation and pleural pressure relationships in dogs breathing first and then liquid fluorocarbon in a whole body water in water respirator<br>[NASA CR 117199]<br>p0068 N71 20358 | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CASSEL, L. A.</b><br>Aerodynamic interference induced by inboard controls<br>[AGARDGRAPH 173]<br>p0184 N74 18923  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CASTELLANI, V.</b><br>On the efficient bandwidth utilization of digital transmitters<br>p0133 N73 10193   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CAVALIERO, F. R.</b><br>Utility of the vertical component of jet flap for control strategies: A diagnostic evaluation<br>p0025 N72 22642  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CEBECI, T.</b><br>Remarks on methods for forced convection flow<br>p0020 N74 14718  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CELLA, A.</b><br>Integer programming algorithm for flight mission scheduling<br>p0296 N74 19004   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CERNANSKY, N. P.</b><br>Factors influencing pilot performance during low altitude egress<br>p0020 N74 14792   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CECHINI, L. J.</b><br>An apparatus for stress corrosion testing with large precracked WOL specimens<br>p0287 N72 21914  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHABRI, J. P.</b><br>A method for periodic tests for pilot performance<br>p0053 N73 19937   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHALF, C. R.</b><br>US Navy STOL landing queue requirements<br>p0038 N72 32022  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHAMBERS, E.</b><br>B2AC engine wear and failure<br>p0058 N74 17716   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHAMBERS, T. V.</b><br>System performance evaluation for advanced aircraft<br>p0080 N73 20493   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHAN, H. L.</b><br>On the laminar flow over a curved airfoil<br>p0025 N72 22642   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHAND, R. R. F.</b><br>Design criteria for a high speed aircraft<br>p0053 N72 19159   | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHANG, N. J. F.</b><br>A method for the use of stress and strain rate data in the design of aircraft structures<br>p0025 N72 22642  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF radars<br>p0121 N72 21126   | <b>COGNIE, D.</b><br>A method for preliminary analysis of MHD generator performance<br>p0065 N73 19051  |
| <b>CHAPIN, J. C.</b><br>A method for the use of stress and strain rate data in the design of aircraft structures<br>p0025 N72 22642  | <b>CHESNUT, W. G.</b><br>Polar propagation effects on VHF/UHF   |   |

- COOK, R. K.**  
Generation and propagation of sound waves between the ionosphere and the lower atmosphere p0134 N73 14134
- COOK, W. L.**  
A summary of wind tunnel research on tilt rotors from hover to cruise flight p0051 N73 21045
- COOKE, J. N. C.**  
Problems in the clinical assessment of raised arterial blood pressure in aircrew p0074 N72 25054
- COOKSON, J. H.**  
Use of hypnotics by aircrew. Considerations of metabolism and excretion p0081 N73 21118
- COOLS, J. J.**  
Design and manufacturing aspects of composite materials with organic matrices for application at high temperatures p0212 N73 27489
- COOPER, G. E.**  
Pilot assessment aspects of simulation [NASA TM 76583] p0172 N71 16069
- COOPER, J. C.**  
Application of a design analysis system to a space shuttle preliminary design p0298 N74 15613
- CORBETT, J. J.**  
Spatial correlation of auroral radio absorption p0129 N72 21146
- CORBIN, M. J.**  
The design of automatic flight control systems to reduce the effects of atmospheric disturbances p0060 N74 17743
- CORKINDALE, K. G. G.**  
Behavioural aspects of aircraft accidents [AGARD R 132] p0106 N74 18797
- CORMIER, P.**  
Aircraft mass p0053 N73 24047
- CORMIER, R. J.**  
Spatial correlation of auroral radio absorption p0129 N72 21146
- CORNFORD, S. G.**  
Turbulence at medium and high flight levels p0057 N74 17721
- CORSET, M.**  
PIGA. Acceleration tests on vertical 15G, 3 Hz table p0236 N74 14347
- COSTE, J.**  
Wind tunnel investigation into aerodynamic interactions induced by dropl loads p0005 N71 19378
- COSTES, J. J.**  
Computation of unsteady aerodynamic forces on helicopter blades p0011 N73 14003
- COUPRY, G.**  
Transfer functions of flexible aircraft to atmospheric turbulence. Minimum required measuring times to perform in stationary measurements in transonic wind tunnels p0173 N73 26243
- COURTIER, J.**  
Application of solid state switching and multiplexing to aircraft electronic systems p0266 N73 19053
- COURTNEY, M. D.**  
The US Navy Special Board of Flight Surgeons. Keep them flying safely p0096 N72 14100
- COUSINE, L. B.**  
The Harwell heat transfer and fluid flow information analysis centre p0113 N71 19536
- COUSSEANS, R.**  
Production of aluminum beryllium composites by hot pressing p0208 N72 12503
- COUSSON, F.**  
School of Navigation Personnel for Tests and Receptions p0036 N72 20993
- COUSTEIX, J.**  
Application of an improved mixing length model to the study of three dimensional boundary layers p0177 N72 20284
- COUTSOUPOULOS, D.**  
Meeting requirements for high temperature gas turbines: a challenge for metallurgists p0259 N71 17389
- COOPERATIVE CREEP TESTING PROGRAMME**  
[AGARD R 581.2.1] p0285 N71 25449
- What are the effects of alloying elements on creep in combination with hot corrosion? p0205 N73 23611**
- COVELLO, R. J.**  
An optimization technique for calculating flutter parameters p0166 N74 13915
- COX, R. M.**  
Sound fields generated by transverse flows over ducts as having a modal character p0214 N72 11876
- Design of ventilated walls with respect to physics of the aspect of noise generation p0184 N73 26285**
- CRAIG, H. L. JR.**  
Progress toward standardization of SOT test results by the American Society for Testing and Materials p0295 N72 21302
- CRAIG, R. J. G.**  
Dynamic safety time delays in shadow systems p0229 N73 20692
- CRAIGIE, J. H.**  
Conceptual analysis of RCM systems p0235 N73 21319
- CRAM, L. A.**  
Modelling of hydrodynamic separation from airfoils p0144 N74 11959
- State of the art and future prospects p0145 N74 11962**
- CRAM, L. R.**  
Introductory lecture. Target scattering characteristics of importance to radars p0144 N74 11955
- CRANE, R. C.**  
Flight testing for turning performance p0036 N72 20969
- CRENSHAW, J. H.**  
Federated vs integrated computer systems p0155 N72 21213
- CRITCHLOW, W. J.**  
On fatigue analysis and testing for the design of the airframe p0295 N73 29930
- CRIMI, P.**  
Dynamic stall [NASA CR 136473] p0018 N74 13769
- CROCHET, M.**  
High frequency backscatter observations at medium latitudes of high latitude fixed aligned irregularities p0130 N72 21149
- CROCKER, R. R.**  
Computer aided placement and routing of high density chip interconnection systems p0168 N74 13937
- CROSBIE, R. J.**  
Dissociating effects of aircraft catapult launches p0129 N72 25037
- CROSS, K. O.**  
Utility of the vertical contact analog display for carrier landings. A diagnostic evaluation p0225 N72 22642
- CROSS, N. L.**  
Ground contamination by fuel jet spray from aircraft p0218 N74 14283
- CROSSLEY, R. J.**  
Effect of posture on tolerance to positive Gz acceleration p0068 N71 20357
- CROSBY, F. L.**  
Laser metrology p0200 N72 25505
- CROUTE, F.**  
Evidence on the effect of natural ionizing radiation on biological stimulation p0075 N72 26050
- CULVER, J. F.**  
History, rationale, and verification of criteria on standards and testing in the United States Air Force p0077 N73 19069
- Human exposure criteria to laser energy p0084 N73 23057**
- Management of glioma in an ageing flying population p0086 N74 13799**
- CUNNINGHAM, W. F.**  
Psychophysiological and environmental factors affecting disorientations in naval aircraft accidents p0071 N72 25236
- CUSTER, D. D.**  
Normalizations for the sequential bithermal biaculation test p0109 N74 20746
- CZINCZENHEIM, J.**  
Experience acquired during the course of high tests and operations utilization of Breguet 941 SOT aircraft p0054 N73 27054

## D

- DAGNINO, P.**  
Determination of an optimal trajectory in the presence of risk p0279 N73 23886
- DAMARA, F.**  
Measure of helicopter noise during flight p0052 N73 21055
- DAMBRE, P.**  
Mathematical properties of grey system response matrices p0207 N72 12493
- DAMON, E. G.**  
The dynamics of an blast p0105 N72 19134
- DANAHER, J. W.**  
Flight crew adaptability to the helicopter cockpit environment p0068 N71 20365
- DANBERG, J. E.**  
A re-evaluation of air pressure gradient compression turbulent boundary layer reattachment p0177 N72 20297
- The suppression of turbulent boundary layer reattachment by pressure gradient. Experimental and data analysis p0179 N72 20349**
- DANEK, G. J.**  
Evaluation of test methods for stress corrosion cracking of aluminum alloys in sea water p0298 N72 21913
- DANESHYAR, M.**  
Prediction of residual wall form for the design of wall form systems p0209 N71 19813
- DANIELS, A. F.**  
A review of manual data control systems. Designing p0224 N72 22629
- DANIELS, T. E.**  
US Army aircraft management. A review of progress p0231 N73 23794
- DARRAS, B.**  
Flight characteristics of a delta wing with a leading edge sweep p0149 N71 29152
- DARWISH, F.**  
Modelling of the aerodynamic characteristics of a delta wing p0207 N72 22416
- DAS, A.**  
A review of the state of the art of the design of a delta wing p0149 N71 29152
- DASAR, J. A.**  
Rapid initialization of inertial navigation sensors through parameter estimation p0228 N73 20693
- DAT, R.**  
Representation of a wing in the lifting line application of the interaction calculations of two wings in tandem p0008 N71 29326
- Application of lifting surface theory to wings provided with control surfaces p0009 N71 29347**
- Acousticity of rotary wing aircraft p0017 N73 22952**
- DAURIA, G.**  
Propagation effects of a variable scatter mechanism p0117 N71 23452
- DAVID, G.**  
Utilization and sampleless of high numerical discharge support in telecommunications p0131 N73 10194
- DAVIES, D. E.**  
Applications of unsteady air force calculation methods to AGARD interference configurations p0009 N71 29342
- DAVIES, K.**  
Some analogies between the propagation of ionospheric radio waves and acoustic gravity waves p0134 N73 14132
- DAVIES, M. C.**  
The effect of interchannel interference on the performance of a phase modulated digital system p0134 N73 10211
- DAVIES, N. G.**  
Performance and synchronization considerations p0143 N73 32057
- DAVIES, P. G.**  
Scatter path attenuation at frequencies above 10 GHz p0142 N73 26140
- DAVIN, A.**  
What are the effects of alloying elements singly or in combination on hot corrosion? p0203 N73 23611
- DAVIS, D. E.**  
Calculation methods for unsteady air forces of tandem surfaces and transonic subsonic flow p0007 N71 29335
- DAVIS, J. A.**  
The pH and potential measurements during stress corrosion of aluminum alloys p0285 N72 21909
- DAVISON, G. A. JR.**  
Recognizing three dimensional objects by their silhouette p0152 N72 11888
- DAY, C. H.**  
Performance measurement using pilot controlled Gz maneuvering with simulated operation at last [AMH TR 72.3] p0106 N73 19154
- DAY, J. W. B.**  
Microwave attenuation measurements using the ATIS 5 satellite p0115 N71 21419
- Comparison of turbulent layer models and high frequency forward scatter results p0119 N71 154**
- DEAN, G. C.**  
Experimental methods for composite materials p0229 N72 29593
- DEAN, P. J.**  
The human factor in naval aircraft accident patterns p0102 N74 18840
- DEAN, R. K.**  
Incident report and failure analysis of pilot error accidents in US Army aviation p0102 N74 18804
- DEBERNARDIS, E.**  
Mission altitude control system for a satellite with flexible bodies p0279 N73 13893
- DEBRUGE, J. M.**  
Aero-optical factors and biometric tendencies during flight p0092 N71 22309
- DECELLES, J. L.**  
A real world situation display for a weather forecasting p0223 N73 23702
- DECKER, R. M.**  
Control Strategy Tests p0035 N72 20588
- DECOUPEL, J.**  
Microviscosity of viscoelastic effects of low frequency rates in polymers p0271 N74 14303
- DEDIEU, J. P.**  
Measure of helicopter noise during flight p0052 N73 21055
- DEGAUDEMARIS, G.**  
Synthesis of a test of efficiency of turbulent flow p0271 N74 14303
- DELAHAYE, R.**  
A review of the state of the art of the design of a delta wing p0149 N71 29152
- DELAHAYE, R. P.**  
Physiological effects of altitude p0102 N72 19146
- Respiratory and metabolic effects of altitude on the human body p0102 N72 19146**
- Radical and chemical effects of the space environment on the human body p0102 N72 19146**
- Environmental effects of the space environment on the human body p0102 N72 19146**
- Environmental effects of the space environment on the human body p0102 N72 19146**
- DELEURY, J.**  
Physiological effects of altitude p0102 N72 19146
- DELOGNE, P.**  
Synthesis of a test of efficiency of turbulent flow p0271 N74 14303
- DETOUR, G. P.**  
The state of the art of the design of a delta wing p0149 N71 29152

# PERSONAL AUTHOR INDEX

EGBERT, D. D.

- DELTOUR, G.**  
Some considerations on the difficulties of dosimetric evaluation and cosmic radiation injuries  
p0075 N72 26049
- DEMAISTRE, J. C.**  
High frequency backscatter observations at medium latitudes of high latitude field aligned irregularities  
p0130 N72 21149
- DEMAW, H.**  
The use of the transistor simulation program SIT-AP for statistical modeling of bipolar transistors  
p0165 N74 15913
- DEMANOE, J.**  
Ejection acceleration. Physiological efforts, tolerance  
p0102 N72 19146  
Modifications of performance under certain medications  
p0080 N73 21110  
Effect of altitude on cerebral blood flow patterns in the smoker and non-smoker  
p0082 N73 21125
- DEMARINES, V. A.**  
Detection of a wide area ground location capability using a synchronized time division multiple access communication system  
p0234 N73 23711
- DEMEESTER, P.**  
Mechanical properties of epoxy-silica composite materials  
p0207 N72 12493
- DEMIS, G.**  
Influence of promoters, free radicals, and inhibitors on diffusion flames  
p0253 N72 11684
- DEPAUL, M. V.**  
Airflow prediction in a collapsible flow  
p0041 N73 15002
- DEQUE, R.**  
Methods of utilizing the results of flight tests for the study of flight performance of the Concorde supersonic transport  
p0034 N72 20978  
Influence of the design and functioning characteristics of the flying control system of a transport aircraft on its flight qualities  
p0340 N72 32032  
Utilization of black boxes for improving the characteristics of pilotage during the aircraft development phase  
p0046 N73 17013
- DEREGT, W. F.**  
Training of personnel to learn the various parts of an information central air vehicle etc. etc. (1 of 2)  
p0158 N73 24205
- DERICHEMONT, G.**  
Wind tunnel flow speed study and flight test of assault Mirage 3's  
p0254 N73 27002
- DERSCHMIDT, H.**  
Wind tunnel experiments for helicopters  
p0173 N73 26246
- DERUYTERE, A.**  
Mechanical properties of epoxy-silica composite materials  
p0207 N72 12493
- DESANTIS, R.**  
Preliminary report on the effects of the influence of meteorological factors on the characteristics of a low altitude transport of A310-4349 (1 of 2)  
p0083 N72 21135
- DESCHAMPS, P. Y.**  
A study of the effects of the weather on the performance of aircraft  
p0124 N72 16705
- DESGARIN, A.**  
Measurement of the shock wave  
p0223 N74 14738
- DESUETE, G.**  
Influence of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DESPRES, S.**  
Some considerations on the difficulties of dosimetric evaluation and cosmic radiation injuries  
p0075 N72 26049
- DESTUYNDER, A.**  
Measurement of the heat transfer coefficient in a turbulent flow  
p0109 N72 20141
- DESIGNES, F.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DETTMERING, W.**  
A new method of the design of the self-heating of the aircraft  
p0252 N72 11682
- DEUTSCH, G. C.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DEVAL, A.**  
Mechanical properties of epoxy-silica composite materials  
p0207 N72 12493
- DEVILIER, P. A.**  
A study of the effects of the weather on the performance of aircraft  
p0124 N72 16705
- DEVRIES, G.**  
Application of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DEVRIES, O.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DEWEY, L. R. JR.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DEWEY, M. E.**  
Calculation and simulation of the effects of two complex search situations  
p0202 N73 19965
- DEWOLF, W. B.**  
Facilities for aerodynamic testing at hypersonic speeds  
p0174 N74 16993
- DIAMOND, P. M.**  
The potential of a system of satellites as a part of an air traffic control system  
p0234 N73 23709
- DICHGANS, J.**  
Self-motion sickness: effects of control efforts and motion sickness induced by optokinetic stimuli  
p0109 N74 20744
- DIEFENDORF, R. J.**  
Fiber and matrix materials for advanced composites  
p0209 N72 29591
- DIEP, G. B.**  
Theoretical and experimental research of take off drag deformation of local surface  
p0041 N73 15001
- DIETZ, A.**  
Cardiologic findings as cause for flying  
p0097 N72 14102  
New findings concerning the importance of arrhythmias  
p0097 N72 14103  
What is the meaning of the master step test in examining pilots to determine the fitness for military flying duty  
p0073 N72 25050  
Use of long-term ECG in aviation medicine  
p0073 N72 25051
- DIETZ, R. O.**  
AGARD study of high Reynolds number wing-turbine requirements for the North Atlantic Treaty Organization  
p0016 N72 11884
- DIJK, J.**  
Some aspects of near and far angle side lobes in double reflector antennas  
p0147 N74 13858
- DILLENIUS, M. F. E.**  
A calculative method for predicting wake separation trajectories at speeds up to the critical speed  
p0035 N73 19379
- DIORENTINO, R.**  
Multi-axis attitude control system for a satellite with flexible loads  
p0279 N73 23832
- DINI, D.**  
Photometric measurements of exhaust smoke trails by jet engine  
p0221 N74 14035
- DINTELMANN, F.**  
Measurements of propulsive efficiency in a jet engine  
p0147 N74 13858
- DION, A. R.**  
A variable frequency antenna system  
p0193 N72 19037
- DIONNE, J. G. G.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DIRUSSO, E.**  
Preliminary report on the effects of the influence of meteorological factors on the characteristics of a low altitude transport of A310-4349 (1 of 2)  
p0083 N72 21135
- DOANE, G. B. III.**  
Measurements of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOBBINGA, E.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOBBIE, T. G.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOETSCH, K. JR.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOHERTY, E. W.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOMINGOS, J. J. D.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DONALDSON, A. B.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DONALDSON, C. O.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DORN, H.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOSSE, A.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOUGHERTY, H. T.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOUKLES, N.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DOVE, D. W.**  
Failure management of multiple gimbal control systems for space shuttle  
p0228 N73 20687
- DOWD, P. J.**  
The USAF SAM selection test and rehabilitation program of motion sick pilots  
p0079 N73 21098
- DRAGANOW, R.**  
Flight tests of the performance of the DO 31 aircraft  
p0035 N72 20481  
DO 31 experimental program: Results and conclusions obtained and future outlook  
p0034 N73 27004
- DRAPIER, J. M.**  
Air Mod. Group on low cycle high temperature fatigue [AGARD R 504]  
p0297 N73 16916
- DREYLING, H.**  
An airline's experience on turbulence  
p0058 N74 17727
- DRINKWATER, F. J. III.**  
Pilot assessment aspects of simulation  
[NASA TM X 66593]  
p0172 N73 16069
- DRISCHLER, J. A.**  
Dynamic loading of aircraft surfaces due to jet exhaust impingement  
p0297 N73 29908
- DRUFUCA, G.**  
Rain attenuation statistics for frequencies above 10 GHz from rain gauge records  
p0147 N73 26135
- DRUMMOND, W.**  
Instating heat exchangers  
p0299 N72 18949
- DUERDEN, F.**  
A computer orientable natural she terming  
p0161 N74 16936
- DUFF, M. J. B.**  
Circular trigonometric significance in pattern recognition  
p0154 N72 11198
- DUFFY, R. A.**  
Summary of new developments at the Dragon Laboratory  
p0227 N73 20686
- DUGAN, J. F. JR.**  
Engine selection for transport aircraft and aircraft  
p0051 N73 24043
- DUKES, T. A.**  
Helicopter IFR flight path control system  
p0033 N72 11933
- DUKES, W. H.**  
Handbook of the material design technology  
[AGARD R 502 21]  
p0004 N73 20197
- DUMAS, G.**  
Comparing between optical and electronic  
p0053 N73 24059
- DUMAS, R.**  
Some basic concepts of thermodynamics at all levels  
p0176 N72 20271
- DUNHAM, J.**  
Heat transfer in a gas turbine engine  
p0257 N71 17374  
Preliminary report on the effects of the influence of meteorological factors on the characteristics of a low altitude transport of A310-4349 (1 of 2)  
p0083 N72 21135
- DUNHAM, R. E. JR.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DUNLEAVY, J. G.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DUPUIS, H.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DURBIN, E. J.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DUTTON, E. J.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DWYER, W.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682
- DYER, F. S.**  
The effects of the shock wave on the self-heating of the aircraft  
p0252 N72 11682

## PERSONAL AUTHOR INDEX

- 8-8

# PERSONAL AUTHOR INDEX

GELLY, R

- FORDHAM, E. L.**  
Fuel related problems in aircraft fuel systems  
p0252 N72 11577
- FORONI, G. P.**  
An integral method for extraction of aerodynamic coefficients from flight test data  
p0036 N72 10991
- FORSCHING, H.**  
Pressure measurements on an harmonically oscillating swept wing with two control surfaces in incompressible flow  
p0010 N71 29350
- FORSYTH, P. A.**  
Ion acoustic waves in a plasma  
p0127 N72 21133  
Angular deviation of radio waves  
p0128 N72 21139
- FORSYTH, P. J. E.**  
The metallographic aspects of fatigue crack fracture toughness  
p0204 N74 23109
- FORTIN, M.**  
The approximation of Navier-Stokes equations for viscous incompressible fluids  
p0191 N72 27297  
Numerical solution of steady state Navier-Stokes equations  
p0181 N72 27298
- FORDICK, G. W.**  
Flight test of a helicopter in three axis dampers  
p0034 N72 11937
- FORSTER, D. N.**  
Some comments on characteristics of high lift wings  
p0277 N72 20065  
The low speed stalling of wings with high lift devices  
p0042 N73 15008  
Some characteristics of transonic flow over airfoils  
p0173 N73 26244
- FOTNER, L.**  
Analytical approach to the loss and defect in behavior of cascades in transonic flow including axial flow variable  
p0268 N73 19900
- FOUQUART, Y.**  
Analysis of turbulent flow over a cascade of airfoils and temperature structures  
p0124 N72 16105
- FOURCADE, M.**  
An automatic navigation system for helicopters  
p0032 N72 11929
- FOURNET, G.**  
Application of superconductivity to high speed aerodynamics using liquid metals  
p0004 N73 19037
- FOX, R. L.**  
Using signed moment in aerodynamics to control a problem  
p0284 N73 20134
- FRADENBURGH, E. A.**  
Aerodynamic factors influencing overall helicopter performance  
p0060 N73 21938
- FRAGA, D. E.**  
A review of the US in service V-STOL programs  
p0254 N72 27503
- FRANCE, J. T.**  
Flight test instrumentation series - Volume 3 - The measurement of fuel flow  
[AGARDOGRAPH 160 VOL 3]  
p0194 N72 25420
- FRANCHINI, E.**  
Fall catalysts  
p0103 N72 19153
- FRANK, R.**  
Aerodynamic factors and conditions for the design of high speed aircraft  
p0092 N71 22307
- FRANKS, W. J.**  
Parametric studies of separating turbulent boundary layer flows  
p0043 N73 15003
- FRAZIER, T. W.**  
Use of spectral analysis procedures for the evaluation of fatigue life  
p0081 N73 21116
- FREARSON, D. E.**  
Mathematical considerations in the development of a computerized aircraft engine test facility  
p0281 N73 23905
- FREDERICKS, R. J.**  
Kaiman flying report and a guide to detection of CW interference on digital telecommunications  
p0133 N73 10210
- FREEMAN, A. P.**  
Initial ground testing for reliability  
p0228 N73 20589
- FREEMAN, G. C.**  
Economics of CAD - A new approach  
p0165 N74 13938
- FREESTONE, M. M.**  
Sound fields generated by transonic flow over surfaces having circular perforations  
p0014 N72 11826  
Design of unsteady flows with general phase shift in the aspect of noise generation  
p0184 N73 26285
- FREY, A. H.**  
Cavitation and cavitation effects on water pumps  
p0068 N73 20154
- FRICK, R. K.**  
Realistic considerations of target acquisition in tactical communications  
p0164 N73 19171
- FRIEDEL, M.**  
Flight maneuver and climb performance prediction  
p0153 N73 24145
- FRIEDRICH, R.**  
Wind tunnel investigations of a specific airfoil type with various boundary conditions at low speed  
p0251 N72 16718
- FRIEHE, C. A.**  
Jet behavior - Dissipation rate measurements in jet flow  
p0178 N72 20597
- FRIHAUGH, J.**  
Radar propagation in the Arctic  
[AGARD CP 97]  
p0126 N72 21121  
High latitude satellite communication  
p0128 N72 21140
- FRISCH, M. A.**  
Potential dynamics  
p0277 N72 12862
- FRISTROM, R. M.**  
Flame inhibition chemistry  
p0252 N72 11688
- FROELICH, G.**  
Causes for permanent grounding and rejection in the ENT Department of the Institute of Aviation Medicine of the German Air Force  
p0097 N72 14101  
Alcohol induced postrotatory horizontal nystagmus - a training through a simple method of detecting slight alcohol intoxications in pilots  
p0072 N72 25039  
Alcohol induced postrotatory horizontal nystagmus - a training through a simple method of detecting slight alcohol intoxications in pilots  
p0075 N72 25060
- FROELICH, G. H.**  
Pure tone hearing losses in pilots of various aircraft age and flying time and its significance for flight speech communication  
p0087 N74 13892
- FROELICH, G. R.**  
Hearing acuity in relation to age and flying time  
p0093 N71 22320
- FROELICHER, V. F.**  
Respiration analysis with abnormal exercise tests and normal recovery programs to flying status  
p0035 N74 13788
- FROMM, J. E.**  
Numerical solution of the Navier-Stokes equations at high Reynolds numbers and the problem of linearization of convective derivatives  
p0181 N72 27295
- FROST, W.**  
Review of data and prediction techniques for wind profiles around mountainous surface obstructions  
p0057 N74 17724
- FRUECHTENICHT, H. W.**  
Duct influences on the flow of light propagation  
p0116 N71 21428  
Phase measurements with microwaves near the sea surface  
p0140 N73 26125  
Explanation of very low level stratospheric winds of subsonic aircraft  
p0148 N74 13868
- FRYER, D. I.**  
Glossary of aerospace medicine terms (English-French and French-English)  
[AGARD AG 153 71]  
p0067 N71 20076
- FUK, K. S.**  
Automatic control of engine speed using a digital computer  
p0152 N72 11184
- FU, Y.**  
The transition to performance of the Defense Communication System  
p0133 N73 10208
- FUCHS, H. S.**  
Clinical causes for grounding  
p0095 N72 14090  
Improved and simplified methods for the clinical evaluation of aircraft part 2  
[AGARD CP 95 Pt 2]  
p0073 N72 25048  
The use of medication and drugs in flying personnel  
[AGARD CP 108]  
p0079 N73 21102  
Technical evaluation report - conclusion - recommendations  
p0080 N73 21103  
Pathophysiological conditions compatible with flying  
[AGARD CP 129]  
p0084 N74 13784  
Technical evaluation report - conclusion - recommendations  
p0084 N74 13785
- FUMS, A. E.**  
Engine and exhaust testing in transonic flight regime  
p0263 N72 16688  
Engine integration and engine design techniques  
p0038 N72 27023  
Engine test for Aircraft Auxiliary Power Systems  
[AGARD CP 104]  
p0063 N73 19030  
Performance of airport engine test facilities  
p0219 N74 14285
- FULACHIER, L.**  
Spectroscopic effects of thermal fluctuations in turbulent boundary layer  
p0175 N72 20216
- FULLER, C. W.**  
Active display of cosmic radiation  
p0075 N72 26047
- FULFIR, G. G.**  
Method of determination of the energy horizon and calculation of dispersion of the altitude determination of sea level  
p0192 N72 19495
- FUNG, A. K.**  
On banked turning in two scale rough surfaces  
[NASA CP 125452]  
p0125 N72 16117
- FUREY, R. J.**  
A study of approach to flight and separation of aircraft in a multi-traffic environment  
p0096 N71 19386
- FURNO, A. L.**  
Fire hazard evaluation of truck and aircraft fuels  
p0212 N72 11689
- FURR, P. A.**  
Overexposure to light and heat  
p0071 N72 25125
- GABEL, R.**  
Control technology for helicopter rotors  
p0056 N74 10910
- GADDES, W. M.**  
Ergonomic considerations of information display and control for design automation systems  
p0169 N74 13938
- GAINES, J. W.**  
Characteristics of life stress in a population of military aviators  
p0088 N74 18787
- GALANTI, C. J.**  
Design of a Kaiman derived fixed gas hybrid navigation system  
p0229 N73 20701
- GALLAGHER, J. T.**  
Simulation and analysis in establishing flying qualities criteria  
p0039 N72 32026
- GALLAGHER, R. H.**  
Optimization of stiffened panels  
p0297 N74 15607
- GALLET, P. M.**  
Flow analysis in axisymmetric subsonic inlets of small gas turbines  
p0265 N72 16701
- GALLINARO, P.**  
Application of non destructive inspection methods to aircraft structures  
[AGARD R 587 71]  
p0197 N72 19541  
Nondestructive inspection of structures  
p0197 N72 19542
- GALLOT, J.**  
Femur - New solution of tail rotor  
p0048 N71 21028  
Prediction of helicopter rotor loads  
p0056 N74 10911
- GALMICHE, P.**  
Thermochemical protection of refractory superalloys for aircraft gas turbines  
p0259 N71 17397
- GALVIN, L. V. P.**  
Acceptance flight testing of military aircraft  
p0036 N72 20987
- GANG, E. C.**  
Avionic systems integration using digital computers  
p0281 N73 23902
- GARDNER, J. E.**  
Hot salt stress corrosion cracking of titanium alloys - Overview and impact on space shuttle application  
[NASA TM X 88304]  
p0289 N72 12976
- GARDNER, L.**  
Jet fuel specifications  
p0251 N72 11669  
Fuel cleanliness  
p0252 N72 11676  
Technical evaluation report on Propulsion and Engine - Panel 37th Meeting on Aircraft Fuels, Lubricants and Fire safety  
[AGARD AP 44]  
p0255 N72 27811
- GARRISON, J. G.**  
Screening tests of susceptibility to stress corrosion cracking  
p0287 N72 21917
- GARTSHORE, I. S.**  
The development of an efficient hovering propeller performance prediction method  
p0050 N73 21049
- GASSMAN, G. J.**  
On modelling the Arctic ionosphere  
p0126 N72 21123
- GAUDET, L.**  
Measurements of the drag of a propeller in a turbulent flow  
p0019 N74 14714
- GAUDISSART, E.**  
Effects due to precipitation on helicopter risks at 12 and 35 GHz  
p0141 N73 26170
- GAUTHIER, M. F.**  
PITULA Program for Turbulent or Laminar Flows - A example of a complex mathematical model in fluid mechanics  
p0182 N72 27308
- GAY, J.**  
Experimental research on the response of aircraft structures to acoustic fatigue  
p0293 N73 29913
- GAYE, M.**  
Nonradiating superconducting coils for energy storage  
p0064 N73 19043
- GE, T. H.**  
An introduction to the laser  
p0199 N72 25494  
Principles of holography  
p0199 N72 25495  
Mathematical methods in coherent optical systems analysis - First order analysis of a holographic storage system  
p0199 N72 25496
- GEISLER, W.**  
Jet simulation and jet interference effects on tailplane  
p0004 N71 9374
- GELL, C. F.**  
Descriptive catalog of atmospheric medical conditions and facilities in the United States and Canada  
p0095 N71 21340  
p0072 N72 25494
- GELLATLY, H. A.**  
Survey of the state of the art of optical fiber technology with a NATO viewpoint  
p0296 N74 15599  
Minimum weightless gas surface effect analysis using the Vortex flow technique  
p0297 N74 15619
- GELFER, W.**  
Incompressible flow through cavities with separation  
p0269 N73 19807
- GELLY, R.**  
Flight generating for hovering at an altitude of 1000 ft  
p0088 N72 14117  
Prediction of the design of a helicopter rotor  
p0039 N72 32026  
Aerodynamic effects of a helicopter rotor  
p0088 N72 18787  
Control technology for helicopter rotors  
p0056 N74 10910

# GEMPERLEIN, H.

- GEMPERLEIN, H.**  
The possibilities of actually testing the combustion characteristics of aviation fuels with appropriate equipment. p0251 N72 11674
- GENET, A. M.**  
Life cycle cost analysis of inertial systems for aircraft and air-to-surface missiles. p0232 N73 20717
- GENEVEY, P.**  
Energy storage and discharge by superconductors. p0064 N73 19041
- GENOT, J.**  
Cooling of turbine blades by liquid metal. p0260 N71 17398
- GEORGE, P. L.**  
HF ray tracing of gravity wave perturbed ionospheric profiles. p0139 N73 14163
- GEORGES, T. M.**  
A 3d tracing for acoustic gravity waves. p0134 N73 14133
- GERBER, C. R.**  
Space station information system requirements: A case history of man-machine system definition. p0279 N73 23887
- GERBER, G.**  
A three axis gyro stabilized torpedo platform. p0230 N72 20702
- GERBER, V.**  
Electronic of a mass spectrometer. p0192 N72 19494
- GERBERT, K.**  
Psychophysiological processes of aging.  
Psychological causes for grounding with special consideration of psychosomatic syndromes and fear of flying. p0093 N71 22319  
Some critical comments on the measurement of flight path strains. p0105 N73 19148  
Fear of flying and its treatment. p0088 N74 18781
- GERHARDT, E. A.**  
Processing and display of time varying spectral information with application to sonar, voice, and medical signals. p0154 N72 11200  
A tutorial on digital technology with emphasis on digital communications and filtering. p0131 N73 10192  
Adaptive equalization without test range systems. p0131 N73 10200  
Some fundamental notions of continuous wavelet theory. p0143 N73 32054
- GERKE, R. J.**  
Ethyl alcohol and pilot performance: Military implications of flight studies. p0081 N73 21113
- GERLACH, O. H.**  
The determination of stability derivatives and performance characteristics from dynamic maneuvers.  
Progress in the mathematical modeling of flight turbulence. p0036 N72 20992  
p0098 N74 17725
- GEWECKE, H.**  
Drug use and performance. p0081 N73 21115
- GHEZZI, U.**  
A method for preliminary analysis of MHD generator performance.  
An experimental research on the behavior of a continuous flow combustor chamber. p0095 N73 19051  
p0220 N74 14296
- GIANNPOULOS, C. E.**  
Medical aspects of grounding and reflight exercises in Military Air Force pilots. p0096 N72 14099  
Management of asymptomatic carriers of Hepatitis Associated Antigen (HAA) in Military Air Force personnel. p0283 N73 23966
- GIBERT, A.**  
Statistical analysis of readiness of flying personnel in the French Air Force. p0096 N72 14098  
A proposed tabular statistical presentation of several results with the PNT. p0108 N74 20737
- GIBERT, A. P.**  
Possibility of predicting psychosocial adaptation process in the selection of pilots. p0278 N73 21094
- GIBSON, C. H.**  
Jet turbine engine: Disposition rate mechanisms and performance. p0178 N72 20792  
Digital techniques in turbine engine research. [AGARDGRAPH 174] p0184 N74 18924
- GIBSON, R. S.**  
Effects of part-whole training procedure upon the acquisition of helicopter skills by the performer. p0176 N73 19163
- GIBSON, T.**  
The ground-air and air-to-air characteristics of a combat mission. p0101 N72 19140
- GIESING, J. P.**  
New developments and applications of the subjective disturbance method for comparing cockpit noise. p0228 N74 29340
- GIESS, M. C.**  
Estimation of the effect of nitrogen oxides on gas turbine engine performance. p0275 N72 21050
- GILES, A. F.**  
A low level evaluation of a... p0100 N73 19100
- GILLIES, J. A.**  
Pilot error of the... p0104 N72 19100
- GILLIS, C. L.**  
Thermal and high speed testing at high... [NASA TM X-7476] p0115 N72 11928

- GILLMORE, K. B.**  
Survey of rotor technology development. p0048 N73 21027
- GILMORE, D. C.**  
The development of an efficient hovering propeller rotor performance prediction method. p0050 N73 21040
- GILYARD, G. B.**  
Flight test experience in aircraft parameter identification. p0046 N73 17012
- GIMENES, C.**  
Synthesis of passive filters with infinite attenuation points realized with weak noise components applied to high degree carrier filters. p0167 N74 13923
- GINOUX, J. J.**  
Heat exchangers  
[AGARD LS 57] p0299 N72 18946  
Supersonic engines  
[AGARDGRAPH 163] p0183 N73 17248
- GIORGI, P.**  
An important characteristic of some traveling ionospheric disturbances. p0138 N73 14156  
Tropospheric influence on the scattering effect due to a mountain ridge at 3 GHz. p0146 N74 13853
- GIRARD, A.**  
Image analysis by multiplex coding. p0125 N72 16114
- GIRARD, B.**  
Energy storage and discharge by superconductors.  
Non-inverting superconducting coils for energy storage. p0064 N73 19041  
p0064 N73 19043
- GLAISTER, D. H.**  
Effect of posture on tolerance to positive Gz acceleration. p0068 N71 20357  
Technical evaluation of the Aerospace Medical Panel Specialists Meeting on Space Acceleration Impairment. p0098 N72 19120  
Emotional and cardiovascular studies of acrobatic flight. Effect of beta receptor blockade on heart rate response. p0105 N73 19149
- GLASER, J. J.**  
Data requirements for turbulence in the earth's atmosphere: shear layer for STOL design criteria. p0059 N74 17107
- GLASS, M.**  
Observations of gravity waves in the high atmosphere by means of meteor radar detection. p0137 N73 14154
- GODDARD, B.**  
Factors affecting the accuracy of sea surface temperature measurements from NITOS SR data. p0124 N72 16107
- GODDARD, K. F.**  
The design of automatic flight control systems to reduce the effects of atmospheric disturbances. p0060 N74 17743
- GOE, G. B.**  
Further remarks about traveling ionospheric disturbances attributed to jet stream activity at mid latitude. p0136 N73 14147
- GOERRES, H. P.**  
Psychological aspects for grounding with special consideration of psychosomatic syndromes and fear of flying. p0093 N71 22319
- GOESSL, H.**  
Directional antennas for a new... p0134 N73 10273
- GOERTHER, B. H.**  
Disturbance characteristics of rotor blades of a compressor under distorted flow conditions. p0073 N71 19370
- GOERTHER, W. H.**  
Liver morphology. p0290 N72 25595
- GULARZDEBOURNE, M. N.**  
Breeding monkeys for biomedical research. p0093 N73 21063
- GOLDBERG, S.**  
Stress studies in testing of human pilots. p0297 N72 21912
- GOLDEN, F. S. C.**  
Orbit cause for grounding: A review of Pilot Nava... 1962-1970. p0095 N73 14022
- GOLDMAN, R. F.**  
Physiological effects of high speed flight. p0071 N71 22304
- GOLDSMITH, P.**  
Range, altitude and maneuverability of a... p0176 N73 19163
- GOOCH, T. G.**  
Stress studies in testing of human pilots. p0297 N72 21912
- GOODSTEIN, R.**  
Development of a... p0226 N72 16002  
Data in the... p0227 N72 21684
- GOODWIN, F. K.**  
Zonal wave number of the... p0100 N73 19100
- GOORNEY, A. B.**  
Assessment of... p0098 N73 18783
- GOSSARD, E. E.**  
Research on... p0123 N72 16107

# PERSONAL AUTHOR INDEX

- FM CW radar studies of prediction of turbulent instability within thermally stable layers by internal waves. p0137 N73 14151
- GOSTOMZYK, J. G.**  
Drug use and performance. p0081 N73 21115
- GOTT, G. F.**  
Digital communications theory. p0143 N73 32055
- GOUARB, M.**  
Possibility of predicting predisposition of man to sickness in the selection of pilots. p0018 N73 21094
- GOUDAT, P.**  
Theoretical and experimental research of take-off drag deformation of local surface. p0041 N73 15001
- GOUGH, M. W.**  
Angle diversity applied to tropospheric scatter systems. p0118 N71 23459
- GOULD, J. M.**  
The NASA computer aided design and test system. p0188 N74 13937
- GOULD, K. G. JR.**  
Analytical evaluation of the phased section concept for oxygen breathing systems. p0093 N73 23065
- GRAF, R.**  
Study of interaction between a beveling fiber and a aluminum matrix. p0206 N72 12507
- GRAHAME, W. E.**  
Recent experience in the transonic testing of two dimensional swept and straight wings with high lift devices. p0072 N72 11860
- GRASSMAN, E. D.**  
Extended electronic and graphic monitoring with emphasis on computer analysis of the records. p0074 N72 25053
- GRATZER, L. B.**  
Analysis of transport applications for high lift vehicles. p0026 N71 20058
- GRAUER, CARSTENSEN, H.**  
Pilot study of large European transonic tunneling tube windtunnel. p0174 N74 18989
- GRAY, J.**  
The role of OSFI in information research and development. p0163 N74 16929
- GRAY, R. B.**  
A vortex analysis of a single blade tip vortex flow and a comparison with experimental data. p0049 N73 21035
- GRAYBIEL, A.**  
Stochastic simulation of... p0092 N71 20314  
Factors contributing to motion sickness susceptibility. Adaptability and susceptibility. p0109 N73 21095
- GRECH, J.**  
A human speech recognition system. p0157 N72 14129
- GREEN, D. A.**  
Alleviated test language for avionics systems. [AGARD LS 54] p0061 N74 22634
- GREEN, J. E.**  
Some aspects of vertical motion disturbances at transonic speeds and their representation in Reynolds number. p0071 N72 11856  
On the influence of free stream turbulence on a turbulent boundary layer: a study of the effect of the level of turbulent intensity. p0184 N73 26281
- GREENING, C. P.**  
The feasibility of looking at a target. p0102 N73 19960
- GREENLEAF, J.**  
Effects of positive Gz acceleration on blood oxygen saturation and peripheral oxygenation. A study of breathing and an experimental investigation of a... p0068 N71 20358  
[NASA CR 117191]
- GREGORIOU, G.**  
Overweight effects on the... p0002 N71 19367
- GREGORY, J.**  
The design and development testing of a new primary helmet. p0104 N72 19162
- GREGORY, P. C.**  
Generation of a... p0226 N72 21682  
Laboratory techniques and evaluation methods. p0227 N72 21688
- GREGSON, F.**  
Fast detection... p0231 N73 20712
- GRETH, W. F.**  
Effects of... p0063 N71 20362  
On the... p0074 N72 11860  
[AMR 18 11 1964] p0074 N73 19076  
On... p0205 N73 19146  
[AMR 18 11 1964] p0205 N73 19146
- GREVENS, H.**  
The use of the... p0144 N74 13937  
For... p0145 N74 13938
- GRIPENTROG, H.**  
Shock wave... p0271 N73 21011
- GRIFFIN, C. R. JR.**  
Stress... p0144 N74 13937  
Preliminary... p0145 N74 13938

- GROBECKER, A. J.**  
United States Department of Transportation research program for high altitude pollution p02 7 N74 14273
- GROBMAN, J.**  
Design and evaluation of combustors for reducing aircraft engine pollution p0221 N74 14302
- GROENKE, K. E.**  
A systematic approach to the study of the connection between emission and ambient air concentrations p0220 N74 14293
- GROSCHE, F. R.**  
Wind tunnel investigation of the vortex system near an inclined body of revolution with and without wings p0001 N71 19355
- GROSE, G. O.**  
Evaluation of the prediction of airplane store interference by linear theory p0005 N71 19381
- GROSSMAN, C.**  
US Army air traffic management now through 1980 p0234 N73 23704
- GRUENINGER, G.**  
Fiber-reinforced materials for application in the cold part of turbine engines p0210 N73 27476
- GRUNHOFFER, H. J.**  
Adaptation and acclimatization in aerospace medicine [AGARD CP 82 71] p0067 N71 20351  
Psychophysiological processes of aging p0093 N71 22319  
Clinical causes for permanent grounding of a crew within the German Armed Forces p0098 N72 14097  
A simplified and improved method for operational anthropometric programmes p0074 N72 25055
- GUDMUNDSEN, P.**  
Extrapolation of propagation data p0142 N73 26137
- QUEDEY, F. E.**  
Assessment of reactions to vestibular disorientation stress for purposes of crew selection p0079 N73 21096
- QUEDEY, F. E. JR.**  
Theory of development of reactions to whole body motion considered in relation to selection assignment and training of flight personnel p0072 N72 25044  
The use of cystagmography in aviation medicine [AGARD CP 128] p0107 N74 20732
- QUEFFIER, G.**  
Radiological study of spinal injuries to pilots undergoing sudden ejection p0102 N72 19146  
Radiological examination of the spine and the combat pilot's capability for duty p0074 N72 25056
- QUIBAUD, A.**  
Flight safety with automatic control requirements and implementation p0031 N72 11918
- QUIGNARD, J. C.**  
Aeromedical aspects of vibration and noise [AGARDGRAPH 151] p0076 N73 17098  
Vibration p0076 N73 17099  
Noise p0076 N73 17100
- QUILLOIS, A.**  
Calculation of aerodynamic interactions between living elements of an airplane in supersonic stationary or nonstationary flow p0002 N71 19362
- QUINARD, H. W.**  
Remote sensing of ocean effects with radar p0122 N72 16991
- QUNYORDAHL, J. W.**  
Guidance and control computer actuated display system techniques p0158 N72 21221
- QURMAN, B. S.**  
The integrated concept procedure for identifying control and display requirements of aircraft in advanced time periods p0223 N72 22625
- QUTTEBERG, O.**  
The influence of precipitation and multipath fading on frequencies between 10 and 18 GHz p0142 N73 26134
- GUYOT, H.**  
Modulus of elasticity measurements on resin fiber composites p0207 N72 12495
- OWIN, L. B.**  
Application of a genetic method for flutter optimization p0297 N74 5609
- H**
- HACKLINGER, M.**  
Design problems of military aircraft as affected by turbulence p0059 N74 17735
- HADINI, J. C.**  
Possibility of predicting predisposition of motion sickness in the selection of pilots p0078 N73 21094  
Aeronautical rehabilitation of flying personnel suffering from acute psychiatric disturbances p0088 N74 13796
- HAFNER, J. F. W.**  
Comparison of mental and psychomotor effects of debarb and ethanol p0062 N73 21126
- HAGFORS, I.**  
Some properties of radar aurora echoes as observed at a frequency of 1295 MHz p0127 N72 21130
- HAINES, A. B.**  
Possibilities for skin effect of swept wings at high subsonic speeds: Recent evidence from pressure plotting tests p0013 N72 11867  
The effect of leading edge geometry on high speed stallings p0042 N73 15010
- HAIMAN, M. F.**  
Exercise tolerance of military personnel p0091 N71 22308
- HALE, H. B.**  
Findings on the cost of flying transport missions p0108 N73 19151
- HALEY, J. L. JR.**  
Analysis of US Army helicopter accidents to define impact injury problems p0099 N72 19129
- HALL, M. G.**  
Scale effects in flow over swept wings p0011 N72 11855
- HALL, M. P. M.**  
Transhorizon propagation studies at VHF and UHF p0116 N71 21426  
Statistics of high level beyond horizon signals at 2 GHz and 2.6 GHz and measurements of the variation of the arrival angle structure p0148 N74 13866
- HALL, P.**  
Introduction to the electromagnetism of the sea p0241 N73 33620
- HALL, P. M.**  
Ionospheric disturbances generated by acoustic gravity waves resulting from a 100 kt to 2000 kt nuclear explosion on the ground, observed at points located between 150 and 1000 km from the firing site p0139 N73 14 67
- HALLS, G. A.**  
Nozzle guide vane cooling: The state of the art p0260 N71 17398
- HAM, N. D.**  
Helicopter blade flutter [AGARD R 607] p0052 N73 21920  
Aerodynamics of rotary wings [AGARD AR 61] p0052 N73 21931
- HAMER, R. G.**  
A computer-aided design system for large scale integrated digital networks p0168 N74 13913
- HAMILTON, W. T.**  
AGARD Flight Mechanics Panel Symposium on Stability and Control [AGARD AR 481] p0041 N73 13018
- HAMMOND, C. E.**  
A compressible unsteady theory for helicopter rotors p0050 N73 21044
- HAMMOND, D. L.**  
Wave height measurements with a nanosecond radar p0122 N72 16094
- HAMMOND, P. K.**  
Aerospace computer input/output techniques p0156 N72 21219
- HANCOCK, G. J.**  
Criteria for stall and post stall gyrations p0039 N72 32029  
Role of fluid dynamics in aircraft stall and costal gyrations p0041 N73 14999
- HANCOCK, J. R.**  
Mechanisms of fatigue in filament reinforced metals p0208 N72 12594
- HANCOCK, P.**  
What is the role of stress in oxidation including both externally applied and growth stresses? What are the modes of stress relaxation? How does thermal cycling affect the stresses and stress relaxation? p0202 N73 23605
- HARDEE, H. C.**  
High intensity direct reading heat flux gauge [SC DR 710194] p0190 N71 36789
- HARDY, D. L. JR.**  
Life cycle cost analysis of medical systems for aircraft and air to surface missiles p0232 N73 20717
- HARDY, J. M.**  
Influence of certain meteorological parameters on aircraft performance p0264 N72 16696
- HARDY, M. E.**  
Vegetation mapping with side looking airborne radar: Yellowstone National Park [NASA CR 125451] p0122 N72 16092
- HARDY, W. G. S.**  
The effects of Reynolds number on rotor stall: Appendix 21 p0018 N73 22957
- HARLAN, W. R.**  
The thousand aviators: A thirty year follow-up p0092 N73 22134
- HARPOULES, G. G.**  
Measurement of atmospheric attenuation at the frequencies of 15, 19 and 34 GHz p0149 N74 13870
- HARPER, R. P. JR.**  
The selection of tasks and subjects of flight simulation experiments p0172 N71 16067  
The role of pilot training in the development of handling criteria p0039 N72 32028
- HARRIS, B. S.**  
Planning and development of computer-aided systems according to a commercial aspect p0158 N72 22173
- HARRIS, C. S.**  
Effects of acoustic stimuli on the vestibular system [ASAE 71 121 191] p0172 N72 25078  
Combined effects of noise and vibration on cognitive and psychomotor performance [AMRL TR 71 115] p0105 N73 19147
- HARRIS, D. G.**  
The use of a flutter-tolerant engine system in a store aircraft engine p0230 N73 20714
- HARRIS, F. D.**  
Aerodynamic and dynamic rotary wing model testing on wind tunnels and other facilities p0018 N73 22955
- HARRIS, G. Z.**  
Instability of laminated composite plates p0212 N73 27488
- HARRIS, K. O.**  
The hunting H 126 jet fighter research aircraft p0027 N71 20066
- HARRIS, R. L.**  
Introduction to spread spectrum techniques p0143 N73 32056
- HARRIS, W. J.**  
The influence of flutter on fatigue: part 3 [AGARD AR 65] p0290 N72 28902
- HARRISON, M. M.**  
Emotional and cardiovascular stresses of centrifugation: Effect of beta receptor blockade on heart rate response p0105 N73 19149
- HARSHA, P. T.**  
Free turbulent mixing: A critical evaluation of theory and experiment p0178 N72 20291
- HART, B. A.**  
Worldwide characteristics of refractive index and climatological effects p0114 N71 21412
- HARTL, P.**  
Avionics in spacecraft [AGARD CP 67 71] p0190 N72 19483
- HARTMAN, R. O.**  
Findings on the cost of flying transport missions p0106 N73 19151
- HARTMANN, G. R.**  
Influence of the troposphere on low incident satellite signals in the range of wavelength 15 to 2 cm p0115 N71 21427  
Satellite correlation between 43 deg and 66 deg northern latitude from 1964 to 1969 p0128 N72 21141
- HARTMANN, K.**  
Force and pressure measurements on a slender delta wing at transonic speeds and varying Reynolds numbers p0012 N72 11863
- HARTZ, T. R.**  
Morphology of radio radar polar propagation effects p0126 N72 21122
- HASKELL, P.**  
An experimental Canopus star sensor p0192 N72 19499
- HAWKES, T. A.**  
Refraction of applied redundancy in the transmission of images p0131 N73 16163
- HAY, J. A.**  
Experimentally determined damping factors p0293 N73 29917
- HAYDEN, J. T.**  
Principles for superconducting generators in aircraft p0064 N73 19036
- HAYTHORNTWHAITE, R. F.**  
An improved approach to selection of high reliability semiconductor components for satellite programs p0191 N72 19487
- HEADLEY, J. W.**  
Recent experience in the transonic testing of two dimensional swept and straight wings with high lift devices p0012 N72 11869
- HEAP, E.**  
Numerical analysis and simulation of turbulence p0226 N72 27687  
Methodological research into command line of sight and homing guidance p0227 N72 27692
- HEARNE, P. A.**  
Some engineering and operational effects of multiple exposures p0225 N72 22626
- HEATH, W. G.**  
Carbon fiber composites: Promises and problems p0210 N73 27477
- HECKMAN, D.**  
Fluid dynamic properties of turbulent wakes of hypersonic spheres p0178 N72 21295
- HEDIARD, M.**  
Modulus of elasticity measurements on resin fiber composites p0207 N72 12495
- HEDRICK, I. G.**  
Fatigue and failure modes of stress for aircraft aircraft p0069 N74 19556
- HEFLINGER, L. O.**  
Physics laser holography [NASA CR 127167] p0193 N72 25551  
Rheology holography p0209 N72 25552
- HEILMANN, W.**  
The influence of relative humidity ratio on compressor cascade performance p0264 N73 19805
- HELD, Y.**  
Proposals for the implementation of the flight test program of platforms p0235 N73 21070
- HEMBACH, H.**  
Use of microstructure through especially at high flying personnel p0097 N73 21123
- HEMINGER, P. M.**  
Microscopic technology for new information displays p0227 N72 22638
- HENENWAY, W. G.**  
Non-attenuation of the power attenuated by atmospheric dust p0129 N74 20746
- HENDERSON, H. T.**  
Control of aircraft engine fuel distribution: A comparison of hydrocarbon fuels p0251 N72 11612



- HENDERSON, R. E.**  
Development and verification of an analytical model for predicting emissions from gas turbine engine combustors during low power operation p0220 N74 14295  
Aircraft gas turbine pollutant limitations oriented toward minimum effect on engine performance p0221 N74 14304
- HENNECKE, D. K.**  
A calculation method for the external heat transfer to turbine blades p0289 N73 19807
- HENNING, C.**  
Text results about the effectiveness of Meizexum applied against motion sickness p0079 N73 21100
- HENROT, J.**  
Stability Augmentation Systems (SAS) p0033 N72 11932
- HENTHORN, M.**  
Stress corrosion cracking of martensitic precipitation hardening stainless steels p0288 N72 21927
- MERCKENRATH, F. W. L.**  
Man-machine combination in the light of safety requirements p0029 N73 23423
- HERNANDEZ PEREZ, M. J.**  
Myocardial and cerebral function during exposure to carbon monoxide p0085 N74 13789
- HERRMANN, J.**  
Impact of new technology as illustrated in an advanced operational data system p0195 N73 10457
- HERZOG, E.**  
Investigation of an accelerated stress corrosion cracking method p0288 N72 21924
- HESS, J. L.**  
Determination of low speed interference effects by superposition p0005 N71 19377
- HESSTVEDT, E.**  
Effect of supersonic transport upon the ozone layer studied in a two dimensional photochemical model with transport p0218 N74 14278
- HESTER, D. E.**  
Lubricant-fuel interactions in advanced aircraft gas turbines [NASA CR 127842] p0254 N72 11694
- HEVENOR, R. A.**  
A mathematical analysis of the propagation and reflection of plane electromagnetic waves in a homogeneous isotropic medium p0123 N72 16100
- HEWITT, B. L.**  
Unsteady airforces for wings with control surfaces. Part 1. Loading functions p0310 N71 29348  
Unsteady airforces for wings with control surfaces. Part 2. Calculation methods p0010 N71 29349
- HEYWOOD, J. B.**  
Parameters controlling nitric oxide emissions from gas turbine combustors p0219 N74 14251
- HIBLER, W. D. III.**  
Automatic processing of Arctic pack ice data obtained by means of submarine sonar and other remote sensing techniques p0121 N72 16088
- HILDEBRAND, R. R.**  
Cruise performance testing of advanced aircraft p0035 N72 20985
- HILGENDORF, R. L.**  
Air to ground target acquisition with flare illumination p0303 N73 19968
- HILL, A. B.**  
A new look at helicopter level flight performance p0047 N73 21014
- HILL, W.**  
Physical conditioning, training and fitness test of German Air Force aircrews p0291 N71 22307
- HILLIER, H. C.**  
Augmentation devices and their effect on the engine. Part 2. Thermodynamic problems and some possible solutions p0226 N71 20062
- HILLIER, W. E.**  
Computer aided design of multilayer printed circuit boards p0168 N74 13934
- HIRSCH, A. E.**  
Protection of the brain from injury during impact. I. Experimental studies in the biomechanics of head injury p0099 N72 19127  
Lethal effects on man of underwater detonation of a flare mine p0100 N72 19135
- HIRSCH, E. H.**  
The influence of the free stream Reynolds number on the influence of the boundary layer on an airfoil swept wing p0193 N74 20280
- HIRST, D.**  
Chip modulation system in advanced satellites p0194 N72 19514
- HIXSON, W. C.**  
Orbital simulation of interplanetary trajectories p0271 N72 25034
- HOCH, G. M.**  
Experimental techniques used to study stress corrosion in austenitic stainless steel p0289 N72 21928
- HOCHWALD, W.**  
Computer aided design analysis of modern large scale structural systems p0161 N74 13928
- HODARA, H.**  
Relaxation of the free surface of a wave p0241 N73 33625  
Experimental results of small angle scattering p0246 N73 33629
- HODGES, B.**  
Criteria for Vision Resolution signal to noise ratio contrast p0242 N73 33631  
Sources: Arc flash incandescent and laser lamps p0242 N73 33633  
Receivers: Photoelectric and photographic detectors p0242 N73 33634  
Spatial filtering and image restoration p0242 N73 33637
- HODGES, J. C.**  
Optimum spaceborne computer system design by simulation p0279 N73 23891
- HODGES, J. C.**  
Aural radar backscatter studies from Homer, Alaska p0127 N72 21129
- HOEFLE, A.**  
Optimization of the layout of trusses combining strategies based on Michell's theorem and on the biological principle of evolution p0298 N74 15617
- HOFFELT, W.**  
Some critical comments on the measurement of flight strains p0105 N73 19148
- HOFFMAN, L. A.**  
Space communications systems considerations at 94 GHz p0143 N73 26143
- HOFFMANN, R.**  
State of art and future trends of computer aided design of microwave integrated circuits p0166 N74 13918
- HOFFMANN, M. A.**  
The effects of INH chemoprophylaxis on aviator performance p0080 N73 21111
- HOFFMANN, O.**  
Satellite television system p0192 N72 19498
- HOFFSTETTER, W. R.**  
Feasibility of testing a large chord swept panel model to determine wing shock location at flight Reynolds number [NASA TM X 67414] p0013 N72 11870  
On the use of free ion 12 for measuring Reynolds number in wind tunnel testing of three dimensional aircraft models at subsonic and supersonic Mach numbers [NASA TM X 67417] p0015 N72 11879
- HOGG, D. C.**  
Depolarization of microwaves in transmission through rain p0141 N73 26127  
Introduction to session 2 p0141 N72 26128
- HOGGE, J. L.**  
An analytical study of linear terminal area intercept geometry and flow control techniques p0233 N72 23701
- HOMOL, R.**  
Operational considerations and applications of the Taurus 4 landing aid to helicopters p0030 N72 11925
- HOLBECH, T. A.**  
Acoustic considerations for noise experiments in model scale in subsonic wind tunnels p0173 N73 26247
- HOLDEMAN, R. E.**  
Initial guidance system crash/missile testing p0236 N74 14348
- HOLDEN, F. M.**  
Performance measurement using a pilot controlled 1/2 mi. hovering with simulated operational task [AMRL TR 72-3] p0106 N73 19154
- HOLDERMANN, F.**  
Generation of line drawings from grey scale pictures p0155 N72 11265
- HOLDERNESS, F. H.**  
Soot formation in rich ketone flames at high pressure p0219 N74 14289
- HOLEHOUSE, J.**  
Some fatigue of a fiber bonded titanium joint in structure p0293 N73 29979
- HOLLAND, M. J.**  
Oxygen 93 turbine cooling p0247 N73 33770
- HOLLINGER, J. P.**  
Remote passive microwave measurements of the sea surface p0122 N72 16095
- HOLLOWAY, R. B.**  
Separation criteria for density peaked shock layers p0035 N71 19383
- HOLM, R. J.**  
A burn area averaged exposure p0233 N73 26368
- HOLME, N.**  
Land navigation system in terms of p0234 N73 23707
- HOLT, E. H.**  
Emission factor propagation of a 1972 aircraft engine in the near field p0174 N72 16108
- HOLLER, M. R.**  
111 band and 112 band radio communication [NASA TM X 74396] p0121 N72 16113
- HOLLET, J.**  
Mathematical model of gas turbine engine p0121 N72 16113
- HOLTZCLAW, B. L.**  
High altitude flying in transonic flow p0122 N72 16113
- HOOPER, J. A.**  
Augmentation devices and their effect on the engine. Part 1. Performance problems between engine and pilot p0225 N71 20061
- HOPKIN, V. D.**  
Thermal stability of a polymer film p0135 N73 23714
- HORLOCK, J. H.**  
Prediction of the growth of boundary layers in heat flow in a tube p0279 N73 23891
- HORSFIELD, W. D.**  
Flight development of the starting characteristics of a military trainer aircraft p0042 N73 15012
- HORTON, H. P.**  
Fundamental aspects of flow separation under high lift conditions p0025 N71 20055
- HOBMAN, R. J. A. W.**  
Pilot vehicle analysis p0040 N72 32034
- HOUBOLT, J. C.**  
The art of determining gust frequency response functions. On turbulence environment and design criteria p0059 N74 17734
- HOUSTON, E. W.**  
Radar Echoing areas of flying animals p0144 N74 11961
- HOWARTH, C. I.**  
Calculation and simulation of the effects of two complex search situations p0302 N73 19963
- HOWELL, D. A. S.**  
The prediction of loading effects on high speed sailing of helicopters p0056 N74 10914
- HUNEN, H.**  
Parameter free and optimization preliminary selection of configuration for prototype design and manufacture p0018 N73 22958
- HUBER, H. E.**  
Influence of elastic coupling effects on the handling qualities of a jetless rotor helicopter p0047 N73 21016  
Some objective and subjective handling qualities to helicopters and V-STOL aircraft p0051 N73 21051
- HUBER, T. E.**  
Spacecraft attitude sensors with emphasis on the orbiting astronomical observatory [NASA TM X 67384] p0277 N72 12863
- HUDDELESTON, H. F.**  
Human pilot modelling p0007 N73 23214
- HUETTER, U.**  
Present and future possibilities of high strength and stiffness to weight ratio composites in primary structures p0111 N73 27481
- HUFF, H.**  
Electric alloys with unidirectional solidification. Study on their use for turbine blades p0213 N73 27494
- HUFFMAN, G. D.**  
The effect of free stream turbulence level on turbulent flow to a flat plate p0170 N73 19790
- HUGHES, G.**  
New techniques in interactive graphical display design facilitating the presentation and manipulation of complex data p0154 N72 11203
- HUGHES, L.**  
Smoke suppression additive effects on particulate emissions from gas turbine combustors p0221 N74 14259
- HUGHES, N. H.**  
The influence of the future landing guidance system on integration of short take off and landing and conventional take off and landing aircraft p0233 N73 23707
- HUGHES, W. G.**  
A live stabilization p0277 N72 12866
- HUGO, M.**  
Investigation of an accelerated stress corrosion cracking method p0289 N72 21924
- HUGUIER, P.**  
Stabilization of Ede and Pede satellites p0278 N72 12862
- HUNG, J. C.**  
Progress in strain wave technology p0279 N73 20699
- HUNSUCKER, P. D.**  
Narrow beam radar investigations of midland side atmospheric structure and motion p0137 N73 14155
- HUNT, W. T.**  
The effect of the propagation of a high data rate transmission at low elevation angles p0115 N71 21422
- HUNTER, I. M.**  
A forward area bombing and landing guidance concept for a tactical aircraft p0234 N73 23708
- HUO, S.**  
Boundary optimization for transonic boundary layer flows p0269 N73 19600
- HURWITZ, H.**  
10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900, 910, 920, 930, 940, 950, 960, 970, 980, 990, 1000 p0299 N72 24059
- HUSSEY, D. W.**  
Behavior of a winged aircraft in a gust p0271 N72 25034
- HUTIN, P.**  
A new approach for the calculation of a turbine engine component response p0066 N74 13747
- HUTTON, P. G.**  
The frequency of a cable driven flywheel p0021 N74 14271
- HYDE, A. S.**  
A comparison of the performance of a new design of a turbine engine p0094 N73 23341

# PERSONAL AUTHOR INDEX

KASVAND, T.

- ILIFF, K. W.**  
Flight test experience in aircraft  
p048 N73 17012
- IMPELLIZZERI, L. F.**  
Structural fatigue analysis and testing for fighter aircraft  
p0060 N74 19655
- INCE, A. M.**  
Ground terminal measurement requirements with respect to satellite communications link availability  
p0133 N73 10203
- INDEN, W.**  
Development results of the ESRO TD satellite pneumatic system  
p0278 N72 12868
- INNES, L. G.**  
The man computer interface problem in terminal automation  
p0235 N73 23718
- IRONSDALE, A. M.**  
What can information do for you?  
p0301 N71 23503
- ISHAMARU, A.**  
Multiple scattering effects on wave propagation through rain  
p0140 N73 26122
- ISOTIA, N. E. C.**  
Aerospace information services: Progress with the ESRO ELDO computerized information network  
p0160 N74 16928
- IVANOFF, P.**  
Solar energy and seasonal thermocline  
p0241 N73 23623  
Physical factors, chemical and biological effects of the propagation of light in sea water  
p0241 N73 23624

## J

- JAARMA, F.**  
Engine airplane interference in transonic test  
p0011 N71 36402  
Inlets airplane testing in transonic wind tunnels  
p0263 N72 16687  
Experimental determination of noise characteristics and noise abatement interference  
p0037 N72 27021  
Facilities for aerodynamic testing at hypersonic speeds  
p0174 N74 16993
- JACOBSON, I. D.**  
Stress characteristics of arbitrary rotating bodies  
[AGARD AG 171]  
p0018 N74 13710
- JACOBSON, M. J.**  
Design and sonic fatigue characteristics of composite material components  
p0233 N73 29318
- JAKENKE, M. G.**  
Introductory remarks: Test technology trends  
p0236 N71 14346
- JAFFE, E. H.**  
Nondestructive inspection practices used in production of composite airframe structures  
p0290 N72 24336
- JAFFEE, R. I.**  
NATO national reports on high temperature corrosion of aerospace alloys  
[AGARD R 59.1]  
p0201 N72 20491  
High temperature corrosion of aerospace alloys  
[AGARD CP 120]  
p0201 N73 23597  
Concluding discussion  
p0203 N73 23617
- JANNKE, L. P.**  
Directionally solidified eutectics in gas turbine design  
p0212 N73 27493
- JAKOBSEN, K.**  
Boron polyimide reinforced titanium fan discs  
p0213 N73 27498
- JAMES, C. A.**  
Some flight experiments on the AH-64 helicopter  
p0047 N73 21335
- JAMES, C. R.**  
Vector thrust in a combat  
p0264 N72 16634
- JAMES, D. J.**  
Chip production system in aeronautical satellites  
p0194 N72 19514
- JAMES, D. O. N.**  
Structural loads and gust criteria  
p0059 N74 17739
- JANTZEN, E.**  
Early stage detection of air changes in gas engines  
p0254 N72 17498
- JARVIS, C. V.**  
Strengthening of an aluminum alloy by exposure to corrosion  
p0208 N72 12507
- JAUCH, P.**  
Photoelasticity of fibrous metal composites by photoelasticity  
p0270 N73 27478
- JAUMOTTE, A. L.**  
Application of power generation  
p0262 N71 25957
- JENSEN, D. R.**  
Remote sensing of tropospheric structure using high resolution radar  
p0123 N72 16497
- JENSEN, F.**  
Computer aided design for maximum production volume or maximum reliability  
p0165 N74 17941
- JESKE, H.**  
Propagation of gravity waves in a stratified medium  
p0176 N72 24427  
The state of water vapor in the atmosphere  
p0176 N71 23374
- JOATTIN, R.**  
Mean wind speed distributions in the atmosphere for forecasting  
p0132 N74 14288

- JOHANSEN, H. K.**  
Penguin missile inertial navigation system design considerations for midcourse guidance  
p0231 N73 20711
- JOHN, R. H.**  
Material and structural studies of metal and polymer matrix composites  
p0212 N73 27491
- JOHNSEN, E. G.**  
Potential teleoperator applications in manned aerospace systems  
p0281 N73 23904
- JOHNSON, E. T.**  
A fluid cooled 2300 F entry temperature axial flow turbine  
p0260 N71 17399
- JOHNSON, H. B.**  
The effects of seming rotors of helicopter autostabilizer design  
p0032 N72 11928
- JOHNSON, H. L.**  
Energy metabolism during exposure to extreme environments  
p0070 N71 20367  
Metabolic imbalances and body hypohydration during food deprivation: 10 days  
p0070 N71 20368
- JOHNSON, I. S.**  
Man role in integrated control and information management systems  
p0278 N73 23882
- JOHNSON, M. G. JR.**  
A 7 aircraft airborne ground and shipboard inertial navigation alignment methodology and results  
p0231 N73 20710
- JOHNSON, R. H.**  
Technical evaluation report on 39th Propulsion and Energetics Panel Meeting on Energetics for Aircraft Auxiliary Power Systems  
[AGARD AR 50]  
p0063 N73 18081  
Developments in aircraft electrical power systems  
p0066 N73 19012
- JOHNSON, S. A.**  
Incidence cost and factor analysis of pilot error accidents in US Army aviation  
p0107 N74 18804
- JOHNSON, W.**  
A computer program for analyzing waveguide structures  
p0166 N74 13919
- JOHNSTON, H. S.**  
Reaction of ozone with nitrogen oxides at high altitudes  
p0217 N74 14274
- JOHNSTON, J. B. B.**  
The operation of helicopters from small ships  
p0046 N73 21019
- JOHNSTON, J. P.**  
The suppression of shear layer turbulence in rotating systems  
p0180 N72 20305
- JOHNSTON, J. V.**  
Compliant surfaces for a bearing gears  
p0229 N73 20695
- JOLY, R.**  
Biological effects of UHF electromagnetic radiation  
p0076 N72 26053
- JONDA, W.**  
Application of composite materials for aerospace structures  
p0211 N73 27482
- JONES, A. C.**  
Presenting a development plan for approval  
p0159 N73 24209
- JONES, C. W.**  
Application of solid state switching and multiplexing to aircraft electrical systems  
p0066 N73 19053
- JONES, D. J.**  
The half cone pressure field and its significance to site mounted radars  
p0053 N71 19367  
Tabular analysis of supersonic flow about circular cones at order 1/2 angle (a equals 1/4 pi)  
[AGARDGRAPH 137 PT 3]  
p0175 N72 15259
- JONES, G. M.**  
Nystagmography: A useful tool in basic flight adaptation investigations  
p0108 N74 20741
- JONES, J. G.**  
Fatigue properties for the assessment of handling qualities during take off and landing  
p0039 N72 12010  
The dynamic analysis of buffeting and related phenomena  
p0043 N73 15018  
Application of energy management concepts to flight path control in turbulence  
p0060 N74 17744
- JONES, J. L.**  
Transport testing in existing wind tunnels  
[NASA TM X 67415]  
p0014 N72 11872
- JONES, J. P.**  
Materials for a manned aircraft  
p0048 N73 21023
- JONES, R. E.**  
Design and evaluation of combustors for turbojet and turbofan engines  
p0271 N74 14312
- JONES, R. K.**  
The dynamics of rotation  
p0106 N72 19134
- JONES, T. V.**  
Heat transfer measurements in short duration hypersonic facilities  
[AGARD AG 167]  
p0300 N73 25945
- JONES, W. L.**  
Wallops Island STOR aircraft  
[NASA TM X 66956]  
p0068 N71 23356  
Reynolds number effects in 1966  
[NASA TM X 67138]  
p0091 N71 23344  
A simple test for the hypersonic flow method for determining the effect of the heat transfer rates  
[NASA TM X 68120]  
p0274 N72 25057  
The aerodynamic characteristics of a hypersonic aircraft  
[AGARD R 110]  
p0083 N74 23057

- Recent NASA aerospace medicine technology developments  
p0083 N73 23058
- JONES, W. P.**  
Unsteady aerodynamics of helicopter rotors  
p0017 N73 14001
- JORDON, R.**  
The effect of leading edge geometry on high speed stalling  
p0042 N73 15010
- JOSELYN, J. A.**  
Propagation of submicrosecond HF pulses through traveling ionospheric disturbances  
p0139 N73 14165
- JOY, J. W.**  
HF measurements of ocean wave directional spectra  
p0148 N74 13867
- JUBE, G.**  
Composites in engine structures and their adaptation to aeronautical needs  
p0211 N73 27484
- JUDD, S. V.**  
Computer optimization of microwave integrated circuits design  
p0160 N74 13920
- JUERGENSEN, K.**  
The NASA computer aided design and test system  
p0168 N74 13931
- JULIENNE, A.**  
Measure of helicopter noise during flight  
p0052 N73 21055
- JULLIEN, M.**  
Interv. at command and control system for aircraft  
p0225 N72 22637
- JUNG, K.**  
Incidence of coronary risk factors in pilots of the Bundeswehr  
p0097 N72 14104
- JUNKER, A. M.**  
Analysis of the vestibulo-ocular counterroll reflex in primates  
[AMRL TR 71 59]  
p0072 N72 25040
- JURGENS, R. B.**  
Propagation of submicrosecond HF pulses through traveling ionospheric disturbances  
p0139 N73 14165
- JURRIENS, A. A.**  
The radar backscatter of vegetation  
p0122 N72 16093
- JUST, T.**  
A new analytical technique for continuous NO detection in the range from 0.1 to 5000 PPM  
p0218 N74 14280  
NO formation in fuel rich flames: A study of the influence of the hydraulic structure  
p0219 N74 14287

## K

- KACPRZYNSKI, J. J.**  
Drag of supersonic airfoils in transonic flow  
p0020 N74 14719
- KAHALAS, S. L.**  
Modeling of nuclear sources of acoustic gravity waves  
p0135 N73 14141
- KAISER, R.**  
Passive dosimetry of cosmic radiation  
p0075 N72 26048  
First results of passive dosimetric cosmic radiation effect on board a prototype of the Concorde GBT supersonic transport  
p0015 N72 26052
- KALB, H. T.**  
Laser metrology  
p0200 N72 25505
- KALIVRETIKOS, C. A.**  
Aircraft core interference  
p0005 N71 19387
- KALMAN, T. P.**  
New developments and applications of the subsonic coupled lattice method for non-linear configurations  
p0008 N71 28340
- KANE, E. J.**  
Considerations of aerodynamic interference in supersonic engine design  
p0001 N71 19356
- KANELAKOS, D. P.**  
Comparison of computed and observed shock behavior from inviscid and near surface nuclear explosions  
p0137 N73 14150
- KANTER, E.**  
Guidance and control computer system design  
p0155 N72 21214
- KAPLAN, H. L.**  
Orbitable detection efforts  
p0081 N73 21117
- KAPLAN, R. E.**  
Intermittent structures in turbulent boundary layers  
p0175 N72 20277
- KAPOSI, A. A.**  
Reliability related to computer aided design and test  
p0165 N74 13909
- KAPLER, G.**  
Exhaust emissions from engines on the GE 164-2 turbo-prop engine  
p0219 N74 14286
- KARDASZ, J. H.**  
Extension of SIMULA 67 for process control  
p0279 N73 23897
- KARDELS, D.**  
Aircraft vulnerability analysis volume 3  
[AGARD AP 47 1013]  
p0061 N74 23502
- KASS, G. J.**  
The effect of surface roughness on structural response  
p0097 N73 23212
- KASVAND, T.**  
Experiments with a hypersonic flow in the presence of an angle  
p0151 N72 17118

- KATZ, A. H.**  
FM: CW HF backscatter observations of radio aurora  
p0130 N72 21151
- KATZ, I.**  
The detection and study of gravity waves with microwave radar  
p0137 N73 14152
- KAUFMAN, J. G.**  
Discussion of paper: influence of test method on stress corrosion behavior of aluminum alloys in seawater by George J. Daniel  
p0288 N72 21920
- KAUFMAN, L. A.**  
An integrated low altitude flight control system for helicopters  
Helicopter guidance and control computer systems  
p0032 N72 11924  
p0156 N72 21223
- KAYADAS, A.**  
Polarization of waves scattered from aurora  
p0127 N72 21133
- KAVRAK, I.**  
Wake characteristics of a two dimensional asymmetric airfoil  
p0052 N72 21054
- KAYNES, I. W.**  
A summary of the analysis of gust loads recorded by counting accelerometers on seventeen types of aircraft [AGARD R 805]  
p0046 N73 20023
- KAYS, W. M.**  
Compact heat exchangers  
p0299 N72 18947
- KAYTEN, O. G.**  
NASA propulsive lift STOL technology program  
p0055 N72 27009
- KAZARIAN, L. E.**  
Age and exercise as factors influencing osteoporosis bone strength and acceleration tolerance  
[AMRL TR 70 74]  
p0068 N71 20359  
The dynamic biomechanical nature of spinal fractures and articular facet derangement  
[AMRL TR 71 17]  
p0101 N72 19139
- KAZMIERCZAK, M.**  
Generation of line drawings from grey scale pictures  
p0155 N72 11205
- KEANE, W. P.**  
Precise IFR hovering: An operational need and a feasible solution  
p0033 N72 11934
- KEARNS, T. F.**  
High temperature corrosion of aerospace alloys  
[AGARD CP 120]  
p0201 N73 23597  
Concluding discussion  
p0203 N73 23617
- KEDDIE, A. W. C.**  
Relative air pollution emission from an airport in the UK and neighbouring urban areas  
p0271 N73 24766  
Relative air pollution emissions from an airport in the UK and neighbouring urban areas  
p0218 N74 14282
- KEELING, M. E.**  
Breeding monkeys for biomedical research  
p0083 N73 22063
- KEHRER, W. T.**  
Handling qualities criteria for supersonic transport  
p0039 N72 32027
- KELLEY, A.**  
Fibre reinforced materials  
p0206 N71 27043
- KELLY, H. B.**  
Medication and drugs in crew  
p0080 N73 21105
- KELLY, L. G.**  
Design and failure criteria of advanced composite primary structure  
p0211 N73 24780
- KENEDY, R. M.**  
The mechanical and structural characteristics of concrete: the issue  
p0101 N72 19140
- KENNAUGH, E. M.**  
Computational and analytical determination of RCS  
p0144 N74 11956
- KENNEALLY, W. J.**  
A design concept for a dual helicopter night shoot system  
p0303 N73 19970
- KENNEDY, R. S.**  
Motion sickness questionnaire and field independence scores as predictors of success in Naval Aviation training  
p0079 N73 21097
- KERR, R. H.**  
Optimum spaceborne computer system design by simulation  
p0779 N73 23891
- KERN, G. E.**  
Acoustic emissions and slow crack growth in high strength steel  
p0287 N72 21917
- KERR, A. W.**  
Integrated motor body loads prediction  
p0057 N74 16316
- KERR, R. I.**  
Optimization of aircraft structures with multiple stress requirements  
p0292 N74 15512
- KETCHAM, S. J.**  
Stress corrosion testing of titanium alloys  
p0287 N72 21912
- KETTERING, G.**  
Pulse Doppler radar guidance: Representative parameters and associated control considerations  
p0227 N7 27691
- KHOT, N. S.**  
Apparatus for studying internal processes in automated design of large aircraft structures  
p0296 N74 15199
- KICMAN, M. O.**  
Application of distributed parameter technique to aircraft design  
p0296 N74 15693
- KING, K. P.**  
Flight investigation of a technique for the measurement of the total and interference drag of external stores  
p0006 N71 19384
- KING, L. S.**  
Studies of aircraft flow fields at inlet locations  
[NASA TM X 68885]  
p0004 N71 19371
- KING, P. F.**  
Current nasal and aural indications for grounding  
p0097 N72 14106  
Aeromedical aspects of vibration and noise  
[AGARDOGRAPH 151]  
p0076 N73 17098  
Hearing conservation in crew and ground support personnel  
p0077 N73 17101
- KING, R. W.**  
The propagation of electromagnetic waves over irregular terrain  
p0146 N74 13848
- KIOCK, R.**  
Influence of the degree of turbulence on the aerodynamic coefficients of cascades  
p0288 N73 19798
- KIRCHHOFF, H. W.**  
Physical fitness in flying including the aging and aged crew  
[AGARD CP 81 71]  
p0091 N71 22301  
Methods of measuring physical fitness  
p0091 N71 22303  
Physical activity and aging  
p0092 N71 22313  
Cardiologic findings as cause for grounding  
p0097 N72 14102  
What is the meaning of the master step test in examinations to determine the fitness for military flying duty?  
p0073 N72 25050  
Use of longterm ECG in aviation medicine  
p0073 N72 25051  
The automatic analysis of the ECG at rest, during and after exercise with two different computer systems  
p0073 N72 25052  
The impact of diurnal rhythm on drug dosing and drug evaluation  
p0082 N73 21119
- KIRKBY, W. T.**  
Some effects of change in spectrum severity and spectrum shape on fatigue behavior under random loading  
p0291 N73 16858  
Some considerations of the fatigue behaviour of aluminum alloy structures under acoustic loading  
p0294 N73 23921
- KIRKPATRICK, D. L. I.**  
Review of two methods of optimizing aircraft design  
p0054 N73 24054
- KIROUAC, G.**  
Information extension services for industry  
p0159 N73 24211
- KIRSCHBAUM, C. V.**  
The automatic analysis of the ECG at rest, during and after exercise with two different computer systems  
p0073 N72 25052
- KIRTLLEY, J. G.**  
Fuels for supersonic and hypersonic aircraft  
p0251 N72 11671
- KISSEL, G.**  
Operational planning of automatic flight control systems for V-STOL fighter aircraft  
p0028 N71 23415
- KISSEL, G. K.**  
V-STOL handling qualities: internal compared with flight test results of the V-STOL Supersonic Fighter VJ 101C and the V-STOL transport aircraft G31E  
p0019 N72 32024  
Power-to-weight influence on stability and maneuverability  
p0045 N73 17008
- KJAERSTAD, O. G.**  
Traction equivalents  
p0165 N74 13914
- KJELAAS, A. G.**  
The influence of precipitation and multipath fading on frequencies between 10 and 18 GHz  
p0142 N73 26134
- KLEIN, K. E.**  
Physical training status in relation to stress tolerance  
p0091 N71 22376  
The prediction of flight safety hazards from drug use and performance decrements with alcohol as reference in flight  
p0081 N73 21172
- KLEIN, R. H.**  
Systematic manual input display design  
[NASA CR 126256]  
p0273 N72 22677
- KLEINHANS, G.**  
Human stress adaptation through simulated pressure conditions in closed shelters  
p0190 N72 12116
- KLEINMAN, D. L.**  
Current status of models for the human operator as a controller and decision maker in mixed aerospace systems  
p0280 N73 23897
- KLEMM, R.**  
Adaptive prewhitening filter  
p0172 N73 16137
- KLOBUCHAR, J. A.**  
Numerical models of total aircraft control over Europe and the Mediterranean and multi-starion constellation comparisons  
[AGARD AG 166A]  
p0187 N74 14094  
A numerical model of TEC over Europe for varying minimum conditions  
p0187 N74 14095  
A numerical model of TEC over the Mediterranean area  
p0187 N74 14096
- KLOPFSTEIN, A.**  
Automatic data acquisition and processing systems  
p0195 N73 10452
- KLOPP, J.**  
Input systems and research for small documentary centers  
p0159 N73 24208
- KLOSTERMEYER, J.**  
Full wave calculations of electron density perturbations caused by atmospheric gravity waves in the F2 layer  
p0136 N73 14145
- KNAPP, S. C.**  
Problems of adaptation to long range large scale aerial troop deployment  
p0069 N71 20360  
Parachuting impact injuries at high drop zone elevations: Environmental effects  
p0101 N72 19137
- KNIGHT, J. A.**  
Design of a Kalman derived fixed gain hybrid navigation system  
p0229 N73 20701
- KNIGHT, J. M.**  
Computer aided evaluation of reconnaissance image compression schemes using an on line interactive facility  
p0131 N73 10191
- KNUDSON, D. R.**  
An experimental test access system  
p0157 N72 22169
- KOCH, A.**  
Physical fitness and flying  
p0091 N71 22302
- KOCH, B.**  
Laser beam probing for aerodynamic flow field analysis  
p0200 N72 25503
- KOCH, C.**  
A contribution to the electronystagmographic method concerning the interpretation of nystagmus characteristics  
p0105 N74 20739
- KOCHENDORFER, R.**  
Fiber reinforced materials for application in the rotor part of turbine engines  
p0210 N73 24776
- KODIS, R. D.**  
The detection of aircraft wake vortices  
p0058 N74 17731
- KOENIG, H.**  
Optimization of automatic flight control concepts for night helicopters with all weather capability  
p0030 N72 11917
- KOESTER, U.**  
German comments on future V-STOL Requirements  
p0055 N73 20703
- KOFSTAD, P.**  
Transport processes in scales in high temperature corrosion  
p0201 N73 23604
- KOLB, A. W.**  
Sonic fatigue resistance of lightweight aircraft structures  
p0294 N73 23923
- KONTUS, J.**  
On the question answering system DELFI and its application  
p0151 N72 11177
- KOGL, J. W.**  
Some remarks on two dimensional laminar separation bubbles  
p0041 N73 15000
- KOPROWSKI, J.**  
Space to motion applications for graphic and control displays  
p0225 N72 22641
- KORNSTADT, H. J.**  
Evaluation of an integrated flight display for the manual IFR landing of VTOL aircraft  
p0224 N72 22631
- KORST, H. H.**  
A study of flow separation in the base region and its effects on powered flight  
p0023 N74 14724
- KOSSIDAS, A.**  
On the question answering system DELFI and its application  
p0151 N72 11177
- KOTHE, K. R.**  
A program for the development of advanced capabilities for collection analysis, production and dissemination of military geograph intelligence  
p0121 N72 16036
- KOVASZNAV, L. S. G.**  
The structure of turbulence in shear flows  
p0178 N72 20290
- KOWALEWSKI, J. F.**  
The dynamic deformation of stiffened shells by rapid loading in tension  
p0298 N74 15616
- KOWALIK, J. S.**  
Feasible direct methods  
p0284 N71 26135
- KRAHE, P. R.**  
For high rate stress corrosion testing of welded joints of aluminum alloy  
p0289 N72 21929
- KRAISS, K.**  
A symbol generator for the atmospheric evaluation of integrated displays  
p0224 N72 22629
- KRATSCHE, K. M.**  
Alarid  
[AGARD AG 161]  
p0299 N72 24954
- KRAUSE, E.**  
Numerical treatment of liquid flow problems  
p0185 N74 22918
- KREFF, S.**  
An aircraft design program and knowledge representation  
p0093 N72 19123
- KREISS, H. O.**  
Boundary conditions for differential equations of type factor differential equations  
p0185 N74 22915
- KREMP, S.**  
Stress analysis of elevated temperature flow pipe fatigue with multibeam  
p0261 N71 17403
- KRETZ, M.**  
Fields of application of geograph intelligence  
p0048 N71 16225
- KROGMANN, U. K.**  
Advanced procedures for self alignment and leveling of aerial platforms  
p0230 N73 20706

## PERSONAL AUTHOR INDEX

## LESCHACK, L. A.

- KROGMANN, V.**  
Advanced Doppler metric navigator for transport helicopter  
p0033 N72 11935

**KROLAK, P.**  
A man machine approach toward solving various routing scheduling and network problems  
p0154 N72 11199

**KRUPP, W. E.**  
Experimental techniques used to study stress corrosion mechanisms in aircraft structural alloys  
p0289 N72 21928

**KRUTZ, R. W. JR.**  
Automated evaluation of the phased duration concept for oxygen breathing systems  
p0083 N73 23065

**KRZYWICKI, H. J.**  
Energy metabolism during exposure to extreme environments  
p0070 N71 20367

**KRZYWOBLOCKI, M. Z.**  
Metabolic imbalances and body hypohydration during food deprivation - 10 days  
p0070 N71 20368

**KUCHARCZAK, M.**  
Controllability and solvability of the wave propagation in troposphere  
p0119 N71 23462

**KUCHTA, J. M.**  
Turbulence and refractivity changes and their serving based upon the wave mechanics theory  
p0125 N72 16116

**KUECHMANN, D.**  
Fire hazard evaluation of incinerated aircraft fuels  
p0253 N72 11689

**KUECHMANN, D.**  
Some remarks on the interference between a swept wing and a fuselage  
p0001 N71 19351

**KUEHL, W.**  
Aerodynamic testing at high Reynolds numbers and transonic speeds [AGARD R 588-71]  
p0016 N72 12978

**KUERSCHNER, D.**  
Experimental investigation on a single stage air cooled gas turbine  
p0259 N71 17387

**KUERSCHNER, D.**  
Orbit determination causes for ground - A 10 years report  
p0097 N72 14508

**KUERNER, G.**  
Practical aspects of color vision and its distribution  
p0277 N73 19067

**KUESSENER, H. G.**  
A comparative study of methods used in flutter research [AGARD R 592]  
p0290 N72 33915

**KUESTER, H.**  
An integral method for approximate calculation of compressible flow over thin airfoils in terms of pressure gradient  
p0176 N72 20278

**KUNNS, P. W.**  
Factors affecting frequency and orbit error in high power transmission satellite systems  
p0133 N73 10705

**KUTNEY, J. T.**  
Antenna propagation system integration analysis using the propagation simulator technique  
p0203 N71 19369

**L**

**LABRUJERE, TH. E.**  
Adaptive beam steering technique applicable to the precision tracking of moving targets with multiple antennas at sea  
p0001 N71 19364

**LAFontaine, E.**  
A proposed hybrid navigation filter with Kalman filtering results using the PN-TL  
p0108 N74 27117

**LAHAYE, C.**  
Fluid dynamic properties of turbulent wakes of hypersonic nozzles  
p0178 N72 21195

**LAHOTIS, D. G.**  
Sequential detection and parameter estimation problem in signal processing Part I - Superresolution  
p0153 N72 11189

**LAMAR, W. E.**  
Handling qualities criteria and requirements  
p0244 N73 16933

**LAMBERT, A. A.**  
Transfer and synthesis characteristics and their evaluation  
p0113 N72 11865

**LAMBERT, J. A. B.**  
The role of quality accelerometers data in tangential production for aircraft engine complexities  
p0294 N73 29927

**LAMBERT, J. F.**  
The RAES - ESOU simulation package for them  
p0295 N73 29932

**LAMBERT, R. F.**  
Automatic flight path control part 2  
[AGARD AT 152 PE 2]  
p0239 N73 14948

**LAMBERT, R. F.**  
Design data for automatic guidance  
[AGARDOGRAPH 162 PE 3]  
p0298 N74 19550

**LAMMERS, U. H. W.**  
Long range flight performance prediction model for long range aircraft  
p0148 N73 21554

**LANGE, W.**  
The repeatability of an abnormal 2 hour glucose tolerance test  
p0087 N74 13805

**LANDGREBE, A. J.**  
Rotor wakes - Key to performance prediction  
p0049 N73 21032

**LANE, J. A.**  
Effects of tropospheric layer structure on propagation and signal distortion  
p0116 N71 21423

**LANGEHESE, G.**  
Current experimental results from a VHF CW auroral backscatter network in Scandinavia  
p0127 N72 21128

**LANGE, W.**  
An electric hydraulic system for simulations of collisions without restraining devices  
p0103 N72 19152

**LANGENBERG, K. J.**  
Propagation of an electromagnetic pulse in a duct between ground and atmosphere layer  
p0116 N71 21425

**LANGLADE, R.**  
Measure of performance - Methods of analysis and application to the Concorde  
p0035 N72 20982

**LANGLOIS, J.**  
In-flight light methods  
p0280 N73 23895

**LANGSHUR, H. H.**  
The state of the art of small gas turbine engines for helicopters and surface transport  
p0262 N71 26953

**LANGSTON, R. P.**  
Maritime pollution  
p0113 N71 19532

**LANGWEIL, L.**  
Wake Vortex Avoidance System program (WVAS)  
p0058 N74 17732

**LANSBERG, M. P.**  
Predictability of motion sickness in the selection of loads [AGARD CP 109]  
p0078 N73 21032

**LANSING, D. L.**  
Dynamic loading of aircraft surfaces due to jet exhaust impingement  
p0292 N73 29938

**LANSING, W.**  
Application of pattern analysis system to a space shuttle vehicle trajectory  
p0298 N74 15611

**LANZARA, A.**  
An approach to multi target assignment problem in combat systems  
p0151 N71 11108

**LANZARA, A.**  
An approach to multi target assignment problem in combat systems  
p0193 N72 19566

**LARSEN, H. N.**  
Engine concept and wind tunnel testing of a turbofan engine for a transport aircraft  
p0256 N72 16706

**LARSON, R.**  
Repetitive vibration in an equatorial culture  
p0148 N74 13865

**LARUELLE, G.**  
Starting conditions of a ramjet engine  
p0267 N72 15715

**LARUSSA, J. A.**  
A world program wide land-based oceanic fleet up to day for anti-aircraft  
p0275 N72 22639

**LATHROP, G. D.**  
Drug administration effects  
p0083 N73 21117

**LAUDE, J.**  
Development of a digital computer program  
p0121 N73 18340

**LAUGHREY, J. A.**  
Acceleration and time response of a microgravity scale performance potential aircraft  
p0071 N74 14716

**LAURENS, R.**  
Effect of a gas turbine  
p0257 N71 25654

**LAWACEK, O.**  
High speed water tunnel of the gas turbine flow  
p0271 N73 19518

**LAWRENCE, J. T.**  
Aerodynamic design and flight test of a delta-wing aircraft  
p0121 N73 18340

**LAWSON, T. V.**  
Problems of a multi-targeted missile  
p0219 N71 14743

**LAYTON, G. P. JR.**  
Propulsion improvement studies  
[NASA TM X 68336]  
p0065 N72 20995

**LAZZARETTI, R.**  
Investigation of the fuel pump and injection system  
p0066 N71 19011

**LE BEAU, R. P.**  
New developments in aircraft noise and sound measurement  
p0102 N71 19263

**LE GRIVES, E.**  
The effect of stress on the human eye  
p0270 N71 17319

**LEADABRAND, R. L.**  
Aircraft safety factors statistics from historical data  
p0121 N72 21128

**LEBAILLEUR, J. C.**  
Prediction of the effect of a large aircraft on the environment  
p0271 N71 19263

**LECARM, M.**  
Rotor requirements beyond the usual flight domain of ONERA large wind tunnel at Mondragon  
p0049 N73 21037

**LECOLO, F. R.**  
Estimates of physiologic response after acceleration exposure in man  
p0105 N73 19150

**LECOMTE, P.**  
Analysis of radiometric infrared sea temperature measurements  
p0124 N72 16105

**LEDoux, B.**  
Velocity distribution at a supersonic compressor inlet  
p0267 N72 16713

**LEDOUC, P.**  
Unit transistor - Model of bipolar transistor having continuous parameters as the geometric dimensions  
p0166 N74 3917

**LEE, A. H.**  
Flight simulator mathematical models in aircraft design  
p0171 N71 16063

**LEE, G. F.**  
Theoretical and experimental investigations of wing-body configurations at low supersonic speeds  
p0002 N71 19358

**LEE, R. E.**  
An experimental study of the compressible turbulent boundary layer with an adverse pressure gradient  
p0175 N72 20299

**LEES, P. R.**  
SCOT satellite communication terminal  
p0133 N73 10204

**LEESSE, J.**  
Factors affecting the accuracy of sea surface temperature measurements from ITOS SRVAs  
p0124 N72 16107

**LEFAUCO, C.**  
IMAG 2 - Electronic circuit simulations  
p0167 N74 13927

**LEFEBVRE, A. H.**  
A preliminary study on the influence of free staging on the oxide emissions from gas turbine combustors  
p0271 N74 14301

**LEFRANCIS, G. H.**  
Intermodulation and fading modulation due to propagation along waveguide and communication  
[CNET TEST APH 1]  
p0117 N71 21433

**LEGER, P.**  
Gas hydrodynamics - Analyzing gas flow with two degrees of freedom - Method of evaluating performance  
p0279 N71 20696

**LEGUY, G.**  
Possibility of predicting and optimizing the performance of a turbine engine  
p0078 N73 21094

**LEHMANN, W.**  
Results of comparative tests on various types of aircraft  
p0083 N73 21120

**LEHMANN, W.**  
Results of comparative tests on various types of aircraft  
p0083 N74 13190

**LEHMANN, W.**  
Results of comparative tests on various types of aircraft  
p0083 N74 13802

**LEGUEN, H.**  
Environnemental properties for simulating the effects of linear acceleration on systems of test articles  
p0098 N73 19121

**LEHMANN, W.**  
Results of comparative tests on various types of aircraft  
p0083 N73 21120

**LEIBOWITZ, T. N.**  
A numerical algorithm and tracking methods employed in the test service of flight data processing systems  
p0278 N73 23884

**LEITH, J. T.**  
Vehicle dynamics and stability - A review of recent developments  
[NASA TM X 68451]  
p0075 N72 20251

**LEMAIRE, R. N.**  
Through water test facility  
p0081 N73 21114

**LEMNINS, A. Z.**  
Binary wrap-around methodology  
p0056 N74 10909

**LENIGLE, G.**  
Signal processing and analysis in combustion chambers

- LESCOP, P.**  
Application of the base composites of carbon fibers and boron wires to compressor blades p0213 N73 27496
- LESUER, R. F.**  
FAA flying qualities requirements p0038 N72 32020
- LEVERETT, S. D., JR.**  
An introduction to the physics and physiology of acceleration p0094 N71 23339  
Estimates of physiologic reserve after acceleration exposure in man p0105 N73 19150  
The use of physiological protective maneuvers in high acceleration environments p0106 N73 19156
- LEVERTON, J. W.**  
The noise characteristics of a large clean rotor p0052 N73 21056
- LEVINE, I.**  
Design of a Kalman derived fixed gain hybrid navigation system p0279 N73 20701
- LEWIN, D.**  
Specification and design languages for logic systems p0166 N74 13930
- LEWIS, A.**  
Fuels for supersonic and hypersonic aircraft p0251 N72 11671  
Electrostatic charging in the handling of aviation fuels p0233 N72 11686
- LEWIS, A. J.**  
Cumulative frequency curves of the Darien Province, Panama p0122 N72 16091
- LEWIS, C. H.**  
Effects of strong axial pressure gradients on turbulent boundary layer flows [NASA CR 125903] p0176 N72 20281
- LEWIS, J. D.**  
A true 3D or flat 2D display p0225 N72 22640
- LEWIS, W. J.**  
Aerodynamics of thrust reverser design p0264 N72 16695
- LEYMAN, C. S.**  
Concorde powerplant development p0285 N72 16705  
The effect of engine failure at supersonic speeds on a slender aircraft: Predicted and actual p0045 N73 17003
- LEYNAERT, J.**  
Transient testing of the engine nacelle air intake and afterbody p0013 N72 11866  
Starting conditions of a mixed compression axisymmetric hypersonic inlet p0267 N72 16715
- LEYSSER, U.**  
Optimization of the exhaust in rockets comprising operating based on Michell's theorem and on the biological principles of evolution p0298 N74 15617
- LIBBY, P. A.**  
Technical evaluation report on AGARD Technical Meeting on Atmospheric Pollution by Aircraft Engines [AGARD AR 63] p0722 N74 15349  
Digital techniques in turbulence research [AGARDGRAPH 174] p0184 N74 18924
- LODDY, S. S. L.**  
Colour vision in the Canadian Armed Forces p0077 N73 19070
- LIEBE, H. J.**  
Attenuation and phase dispersion in the atmosphere due to the microwave spectrum of oxygen p0141 N73 26126
- LIEBESNY, F.**  
Education and technical training for technical information p0160 N74 16931
- LIEBS, C.**  
Application of film cooling to gas turbine blades p0260 N71 17394
- LIEVENS, C.**  
The estimation of aerodynamic coefficients necessary for performance calculations p0053 N73 24046
- LIGHT, W. R., JR.**  
Design of a Kalman derived fixed gain hybrid navigation system p0229 N73 20701
- LIKINS, P. W.**  
Passive and semi-active attitude stabilization: Dual spin satellites p0277 N72 12864  
Passive and semi-active attitude stabilization: Flexible spacecraft p0277 N72 12865
- LILL, T.**  
Injection of a turbulent boundary layer wall with a strange gas p0180 N72 20303
- LIN, J. C.**  
Multiple scattering effects on wave propagation through rain p0140 N73 26122
- LINDBERG, E.**  
The teaching of CACA in Denmark p0165 N74 13907
- LINDBERG, G. M.**  
Accurate finite element modeling of flat and curved stiffened panels p0293 N73 29311
- LINDEN, R. L.**  
Integrity of ICAI systems p0228 N73 23721
- LINDENBAUM, B.**  
A review of the US In-service V-STOL programs p0054 N73 27003
- LINDHOUT, J. P. F.**  
A calculation method for three dimensional incompressible turbulent boundary layers p0177 N72 20285
- LINDQUIST, O. H.**  
Design implications of a total view of the multichannel capacity of a port p0223 N72 22626
- LINDSTROM, E. E.**  
Medical elimination of students undergoing primary flight training p0073 N72 25049
- LIONS, J. L.**  
On the numerical approximation of some equations arising in hydrodynamics p0181 N72 27295
- LIPMAN, R. L.**  
Estimates of physiologic reserve after acceleration exposure in man p0105 N73 19150
- LIPSCOMB, M. L.**  
Inertial system enhancement of flight control p0229 N73 20700
- LISSAC, R. B.**  
Hot salt stress corrosion cracking of titanium alloys: Overview and impact on space shuttle application [NASA TM X-68304] p0289 N72 21926
- LISTER, J. A.**  
Results of behaviour therapy in flying phobia p0098 N74 18782
- LIUSKA, L.**  
Polar propagation effects on radio astronomical and satellite transmissions p0128 N72 21137  
Detection of 2 Hz infrasound produced by moving auroral electrodets p0135 N73 14138  
On the generation and detection of artificial atmospheric waves p0138 N73 14161
- LITVA, J.**  
Observations of travelling ionospheric disturbances at London, Canada p0138 N73 14158
- LIU, C. H.**  
On waves generated by stationary and traveling sources in an isothermal atmosphere under gravity p0135 N73 14139
- LIVINGSTON, E. C., JR.**  
Proving the operational capability of a high performance flight control system p0027 N71 23413
- LLEWELLYN JONES, O. T.**  
The influence of radiation on line of sight propagation at 110 GHz in SE England p0142 N73 26136
- LLEWELLYN, A. I.**  
Economics of CAD: A new approach p0165 N74 13908
- LLOYD, D. A.**  
The exponential probability distribution and its use in assessing the performance statistics of aerospace systems p0281 N73 23903
- LOCA, H. L.**  
Theoretical and experimental investigations of wing/body configurations at low supersonic speeds p0002 N71 19358
- LOCKMAN, V. O.**  
Vegetation mapping with side looking airborne radar: Yellowstone National Park [NASA CR 125451] p0122 N72 16092
- LOEHMKE, R. I.**  
Experiments on management of free stream turbulence [AGARD H 598] p0184 N72 33267
- LOENDORF, D.**  
Automated wing planform structures by mixed optimization methods p0297 N74 15617
- LOESER, H.**  
Advanced power generation in missiles p0055 N73 19044
- LOEVE, W.**  
An approximate method for the calculation of the pressure distribution on wing/body combinations at subcritical speeds p0003 N71 19364
- LOEW, M. H.**  
Automated medical diagnosis using nonparametric sequential classification procedures p0152 N72 11184
- LOFTING, R. G.**  
V-STOL in the Royal Air Force: Some lessons from the first 18 months p0029 N71 23427  
A review of United Kingdom (RAF and Army) statistics on spatial disorientation in flight 1960-1970 p0071 N72 25033
- LOMAX, J. B.**  
Propagation limitations in remote sensing [AGARD CP 90-11] p0121 N72 16085  
Frequency distortion in auroral HF propagation p0179 N72 21143  
Nuclear weapon effects on the ionosphere of a region p0149 N73 14159
- LOMBARDO, S.**  
Experience with transpiration cooled blades p0159 N71 17394
- LONGLEY, A. G.**  
Predictors of tropospheric radio transmission losses over irregular terrain p0120 N72 23472
- LONGO, L.**  
The psychophysical method of variation: psychophysics in the treatment of some syndromes of a reflexive character p0059 N73 19355
- LOREA, A.**  
Aerodynamic testing on the VFW Fokker VAX-191 B structural components p0294 N73 29970
- LORENZ MEYER, W.**  
Simulation of two dimensional turbulent flow at high subsonic Mach numbers and high Reynolds numbers: means of an equivalent body of revolution p0034 N72 11874  
Predictions of a large European transonic Ludwig Tube windtunnel p0174 N74 16989
- LOTEN, K.**  
Nozzle-airframe interference and integration p0037 N72 27020
- LOUBET, R.**  
Keynote address p0292 N73 29906
- LOUDET, C.**  
Design of small dimension turbine blade by theoretical analysis p0258 N71 17380
- LOUET, J.**  
TAM-TAM system p0234 N73 23710
- LOWDER, H. B.**  
Correlation between laboratory tests and service experience p0291 N73 16901
- LOWRY, L. R.**  
Superconducting electrical machinery p0064 N73 19040
- LOWSON, M. V.**  
Fundamental Consideration of Noise radiation by rotary wings: Helicopter noise: Analysis, prediction and methods of reduction p0052 N73 21053  
p0017 N73 22953
- LU, S. S.**  
Structure of the Reynolds stress near the wall p0175 N72 20275
- LUCAS, E. J.**  
Superconductivity in steady state and pulsed applications for flight vehicles p0063 N73 19035
- LUCAS, R. M.**  
Industrial and technological problems of small gas turbines for helicopters and ground transport p0262 N71 26956
- LUCCHESINI, M.**  
Photometric measurements of exhaust smoke trails by jet engines p0221 N74 14305
- LUDWIG, H.**  
Project study of a large European transonic Ludwig Tube windtunnel p0174 N74 16989
- LUKASIEWICZ, J.**  
Aerodynamic test simulation: Lessons from the past and future prospects [AGARD R 603] p0172 N73 18250
- LUNDQUIST, G. E.**  
Status and trends in civil air traffic control systems p0233 N73 23696
- LUSINCHI, J. P.**  
SIGMA: An integrated system of computer-aided complex circuit designs p0168 N74 13932
- LYNCH, P. J.**  
Sea brightness temperatures at minimum frequencies p0124 N72 16110
- LYNN, H.**  
Pulse doppler missile guidance: Representative parameters and associated fire control considerations p0227 N72 21693
- LYON, C. C.**  
Retrieval of microfiche: Random access p0160 N74 16934
- LYON, G. F.**  
Ionospheric waves in aurora p0127 N72 21132  
Angular deviation of radio waves p0128 N72 21139
- LYON, H. B., JR.**  
Guidance and control displays [AGARD AR 43] p0194 N72 25419

## M

- MAANDERS, E. J.**  
Some aspects of near and far angle systems in double reflection antennas p0147 N74 13858
- MABEY, D. G.**  
Some boundary layer measurements on a flat plate at Mach numbers from 2.5 to 4.5 p0177 N72 20288
- MABSON, W. E.**  
Human response criteria to laser energy p0084 N73 23007
- MACCHI, E.**  
On the application of a time dependent technique in transonic flow field calculations p0266 N72 16713
- MACCORMACK, R. W.**  
Survey of computational methods for steady flows over supersonic airfoils, flows with shocks p0185 N74 13919
- MACDONALD, H. I.**  
Survey of rotary wing loads and stability analysis problems p0348 N73 27327
- MACDONALD, J. A.**  
Fire and explosion protection of fuel tank off-gas p0253 N72 16697
- MADE, W. G.**  
AGARD flight test instrumentation series: Volume 2: Flight instrumentation measurements [AGARD AR 150 VOL 2] p0196 N73 20499  
AGARD flight test instrumentation series: Volume 4: The measurement of engine static speed [AGARD AR 160 VOL 4] p0108 N74 14116
- MACFARLANE, J. J.**  
Scal formation in high speed flame at high pressure p0213 N74 14269
- MACKAY, G. M.**  
An assessment of active and passive structural control systems: Comparison of active and passive systems p0091 N72 13190
- MACNAB, R. I.**  
Project study of a large European transonic Ludwig Tube windtunnel and operational experience p0174 N74 16988

**METGES, P J**

- B-17

- METZGER, D. E.**  
Evaluation of film coating performance on gas turbine surfaces p0260 N73 17395
- MEYER, DEJOUR, J.**  
Physiological studies of fatigue in activities requiring mental concentration in the climate, the influence of positioning and sensorial irritation. p0106 N73 19155
- MEYER, ERKLENZ, J. D.**  
Combined environmental, emotional and physical activity therapy: A modern preventive and reconditioning program p0092 N71 22316  
The automatic analysis of the ECG at rest, during and after exercise with two different computer systems p0073 N72 25052
- MEYER, C. S.**  
A computer-aided design system for large scale integrated digital networks p0168 N74 13933
- MICHAELSEN, O. E.**  
Application of V. STOL handling qualities criteria to the CL 84 aircraft p0038 N72 32023
- MICHARD, J.**  
Heat flux measurements on test turbine blades p0257 N71 17378
- MICHEL, R.**  
Application of an improved mixing length model to the study of three dimensional turbulent flows p0172 N72 20284  
Prediction of turbulent boundary layer wall with a simple gas Techn. evaluation report on the AGARD Specialized Meeting on Turbulent Shear Flows [AGARD AR 40] p0182 N73 11262  
Method of calculating three dimensional turbulent boundary layer separation with application to a simple turbine blade case p0270 N73 19808
- MIDDLETON, P.**  
Minimum time trajectory computation: Development of the Balachynsky method p0253 N73 24053
- MIDDLETON, W. D.**  
Conservation of aerodynamic interference in system airplane design p0031 N71 19356
- MIRKELSON, D. C.**  
Flight and wind tunnel investigation of static stability effects on underwing external store exhaust flow characteristics p0204 N74 16887 [NASA TM X 66887] p0203 N71 19366
- MIXUS, T.**  
Parameters controlling nitric oxide emissions from gas turbine combustors p0119 N74 14291
- MILLET, R. J.**  
Precision IR hovering: An optical stabilized and feasible solution p0033 N72 19334
- MILLER, E.**  
Factors affecting frequency and orbit variation by high power transmission satellite systems p0133 N73 10205
- MILLER, P. M.**  
Automobile structural crashworthiness for computer crash protection p0101 N72 19142
- MILLER, R. E.**  
Simulated crash tests as a means of rating aircraft safety levels p0254 N72 11692
- MILLER, R. H.**  
A review of past AGARD NATO activities on V. STOL: a study of their applications p0254 N73 27021
- MILLER, T. H. JR.**  
A. B. A. data computer and operational performance: US Marine Corps p0054 N72 27005
- MILLER, W. B.**  
Correlation between laboratory tests and service experience p0291 N73 16901
- MILLMAN, G. H.**  
Tropospheric effects on space communication p0114 N71 21413  
Tropospheric refraction effect on the geometry of field alignment p0130 N72 21352
- MILOSEVIC, L.**  
Integration of communication functions: navigation identification and traffic control p0235 N73 23717
- MILSON, L. W.**  
Integration of auxiliary power systems with the main spool engine p0065 N73 19049
- MIMB, J. L. III.**  
History, rationale and verification of color vision standards at testing in the United States Air Force p0069 N73 10669  
Management of glaucoma in a flying population p0086 N74 13799
- MINE, J.**  
Aircrew's fitness for flying duties after venereal fractures and spinal surgery p0086 N74 13794
- MINER, F. W.**  
Effects of strong axial pressure gradients on turbulent boundary layer flows [NASA CR 125903] p0176 N72 20281
- MIMB, P.**  
Experimental method of measuring propagation attenuation of rain p0142 N73 26138  
Rate of atmospheric ducting: the phenomenon of multiple over large distances p0146 N74 13849
- MITCHELL, A. J.**  
The use of Rayleigh spectra and turbidity for assessing subjective estimates of important parameters for target acquisition p0304 N73 19973
- MITCHELL, R. E.**  
The thousand aviators: A thirty year follow up p0092 N71 22314  
The thousand aviators: Aging and the blood pressure p0084 N74 13786
- MIXSON, J. S.**  
Dynamic loading of aircraft surfaces due to jet exhaust impingement p0252 N73 29908
- MOE, W.**  
Session 4: Design: Opening remarks p0220 N74 14297
- MOEHMANN, K. H.**  
The adaptive identification of transmission systems p0132 N73 10199
- MOELKER, J. J. P.**  
Man-machine combination in the light of safety requirements p0029 N71 23423  
Summary of AGARD Meeting on Problems of the Cockpit Environment: November 1968 in Amsterdam, Netherlands p0044 N73 18990
- MOELLER, H. G.**  
Polar propagation effects on HF radars p0129 N72 21142
- MOGENSEN, G.**  
Improved data for propagation analysis p0141 N73 26132
- MOHLER, S. R.**  
The current status of drug use in civil aviation performance p0080 N73 21104
- MOHR, G. C.**  
Performance measurement using pilot controlled G-manuevering with simulated operational tasks [AMRL TR 72-3] p0106 N73 19154
- MOHR, W.**  
Depolarization of dipole radiation in a medium with a statistically homogeneous and isotropic distribution of dielectric constant p0119 N71 23460
- MOJOLA, O. O.**  
An experimental investigation of the turbulent boundary layer for a shockwave corner p0190 N72 20302
- MOLE, C. J.**  
Superconducting electrical machinery p0054 N73 19040
- MOLLIC, P.**  
Integration of communication functions: navigation identification and traffic control p0235 N73 23717
- MOLIZZI, A. R.**  
An improved approach to the solution of high instability problems for components for static programs p0191 N72 19487
- MONEY, K. E.**  
Two special kinds of dissemination systems: Jernsper and grant hard p0072 N72 25041  
Measurement of susceptibility to motion sickness p0078 N73 21093
- MONFORT, M.**  
Engineering analysis p0172 N71 16088
- MONNERIE, J.**  
A new technique for aerolift leading edge studies p0027 N71 20614
- MONTANARI, U.**  
Computer processing of natural stresses: Some practical problems p0152 N72 11186
- MONTEFUSCO, N.**  
Computer design of equal ripple equalization p0167 N74 13924
- MONTEL, G.**  
The SAVVAN: Means for inspection by OR and DME p0232 N73 23695
- MONTI, H.**  
Wind correction for airplanes with lift augmentation wind tunnel tests p0011 N71 26453  
Tenth AGARD Meeting report on Progress and Needs of Panel 38th Meeting on Inlets and Nozzles for Aerospace Engines [NASA TM X 67241] p0267 N72 21819
- MOO, C. A.**  
Generation of anomalous ionospheric oscillation by substorms p0136 N73 14148
- MOORE, F. G.**  
Aerodynamic drag and lift of general body shapes at subsonic transonic and supersonic Mach numbers p0019 N74 14712
- MOORE, R. K.**  
Radio imaging applications: Past, present and future p0121 N72 16030  
Workshop on radar scattering held Tuesday, June 19, 1973 p0126 N72 16119
- MOORE, V. S.**  
The combined ionospheric type and protection afforded by severe commercial loadings on two night base arrays [NASA CR 116374] p0259 N71 17393
- MOORHOUSE, D. J.**  
A practical look at the state and high speed operation of externally blown flap STOL transport configurations p0042 N73 10044
- MOORTHAMERS, R.**  
Analytical study of the causalities of medical usefulness of flying personnel in the Belgian Air Force p0095 N72 14093
- MORAITIS, S. N.**  
Research and development activities in Greece p0335 N74 21551
- MOREAU, R.**  
Automatic tracking of Q-switched laser rangefinders p0194 N72 19513  
A French column: Avionics systems of time frequency type: Critical analysis of test results p0235 N73 23717
- MOREL, A.**  
Brief on the theories of radiative transfer application to propagation in the sea p0241 N73 37822  
Diffusion of light by sea water: Experimental results and theoretical approach p0241 N73 33627
- MORIT, J.**  
Visibilities of LRBA in the medical domain p0231 N73 21714  
Determination of coefficient of electrometers by a method of differential tests p0231 N73 20715
- MORETTI, T.**  
Numerical analysis of viscous one dimensional flows p0181 N72 27300  
A critical analysis of numerical techniques: The piston driven mass flow p0181 N72 27301  
Transient and asymptotically steady flow of an inviscid compressible gas past a circular cylinder p0181 N72 27302  
The blunt body problem for a viscous rarefied gas flow p0182 N72 27303  
The choice of a time dependent technique in gas dynamics p0182 N72 27304
- MORGAN, A. D.**  
The effect of atmospheric disturbances on the bearings of incoming sky waves p0138 N73 14159
- MORGAN, F. E.**  
Formal diagnosis system testing p0237 N74 14335
- MORGAN, O. E.**  
A practical application of pattern recognition p0152 N72 11182
- MORGAN, T. J.**  
Multiphoton and spectroscopic systems: A state of the art review p0160 N74 16932
- MORISSETTE, Y.**  
Oculomotor diagnosis: Its value in the diagnosis of certain vestibular lesions p0109 N74 20742
- MORRIS, A. J.**  
The optimization of static stability characteristics of vehicles by means of approximate geometric programming p0296 N74 15602
- MORRIS, A. W. H.**  
Risk strengthening in test bed tests p0259 N71 17390  
A limited review of the application of advanced fibrous composites to gas turbine engines p0212 N73 21490
- MURKISS, D. P.**  
Gas turbine power plant development p0265 N72 16705
- MORSE, F. H.**  
Automatic processing of Air Force data obtained by means of submarine sonar and other remote sensing techniques p0121 N72 16088
- MOSES, F.**  
Optimization of structures with reliability constraints p0284 N71 20138  
Recent developments in the Case optimization program p0296 N74 15600
- MOSIER, S. J.**  
Development and validation of an analytical model for predicting emissions from gas turbine engine combustors during low power operation p0220 N74 14295
- MOSKO, J.**  
Growth and recovery of temporary threshold shifts following extended exposure to high level continuous noise p0067 N71 20353
- MOTKOWITZ, S. L.**  
Experience with transpiration cooled blades p0258 N71 17384
- MOSS, G. F.**  
The effect of leading edge geometry on high speed stall p0042 N73 15010
- MOTT SMITH, J. C.**  
Computer aided evaluation of reconnaissance image compression schemes using an on-line interactive facility p0131 N73 10191
- MOULDEN, T. H.**  
Bases of reevaluation of jet engine speeds: The estimation of Reynolds number effects p0012 N72 11864
- MOWER, R. D.**  
An analysis of multispectral images for tropical land use classification p0124 N72 16111
- MOZER, G. R.**  
Inertial guidance system site testing p0137 N74 14354
- MÖLLER, M.**  
The application of computerized MOS systems in aircraft systems as a qualification test p0192 N72 19507
- MUCKER, F. A.**  
Free and applied a synthesis for pattern recognition: Problems, theory and application p0152 N72 11181
- MUEHLENFELD, E.**  
Optical pattern processing for recognition p0114 N72 11190
- MUELLER, K. R.**  
On activities for permanent monitoring of aircraft in the German Armed Forces p0295 N72 14093
- MULHEIM, J. H.**  
The use of a computer model and the growth of stress corrosion cracks in a high strength alloy p0287 N72 21908

- MURDOCK, J. W.**  
Conceptual mission and duplication of scientific and technical information analysis centers p0113 N71 19527  
Proposals for an international air pollution information analysis center p0113 N71 19531  
Concept of vision and operation of scientific and technical information analysis centers p0301 N71 23507
- MURMAN, E. M.**  
Computational methods in viscous fluid flows with embedded shock waves p0182 N72 27306
- MURPHY, B. L.**  
Modeling of nuclear sources of acoustic gravity waves p0135 N73 14141
- MURPHY, F. H.**  
Fault isolation and maintenance concepts of an advanced internal navigation system p0231 N73 20713
- MURPHY, J. N.**  
Fire hazard evaluation of thickened aircraft fuels p0253 N72 11689
- MURPHY, J. P.**  
Statistical propagation model for irregular terrain paths between transposition and mobile antennas p0120 N71 23473  
An integrated low altitude flight control system for helicopters p0332 N72 11924
- MURPHY, J. V.**  
The integrated cockpit procedure for identifying cockpit and display requirements of aircraft in advanced time periods p0223 N72 22525
- MURRAY, I.**  
Industrial heat exchangers p0299 N72 18943
- MYKTYOW, W. J.**  
Application of ARFOL unsteady load prediction method to interfering surfaces p0069 N71 29341
- N**
- NAGEL, M. R.**  
A model for the inherent contrast conditions in light from stars p0303 N73 19966
- NAGIB, H. M.**  
Experiments on management of free stream turbulence [AGARD R 598] p0182 N72 33267
- NARAHARA, R. A.**  
The occurrence of hypoxemia during flight and confounding subjects of the GAOASW aircrew study p0087 N74 13803
- NARDI, G.**  
Low emission fuels and devices for aircraft engines p0251 N72 11675
- NATALLI, F. D.**  
Optical equivalent flux receiver technology p0132 N73 10736
- NATHIE, J.**  
Statistical analysis of usefulness of flying personnel in the French Air Force p0096 N72 14598
- NAYLOR, R.**  
Computer aided placement and routing of high density chip interconnection systems p0168 N74 13737
- NEALE, M. C.**  
Some recent research on supersonic intakes in NGTE p0064 N71 19372
- NEIGHBOR, T. L.**  
Handling qualities criteria for helicopters p0143 N73 16993
- NELSON, A. W.**  
Data on exhaust emissions measured at three different altitudes p0211 N74 14275
- NELSON, J. M.**  
A management decision tool for waiting and service scheduling and network problems p0154 N72 11733
- NELSON, R. A.**  
Comparisons of computer and observed shock heights from microfilm and near surface laser experiments p0137 N73 14150
- NETHAWAY, J. E.**  
The ergonomics of operating helicopter controls p0031 N72 17979
- NEU, C. E.**  
Stress response to loading of the cervical spine p0787 N72 21372
- NEUBERT, H.**  
Computer aided layout of graphic information which is changing under external control of display equipment and human structures p0152 N72 27776
- NEVINS, J. L.**  
Man-machine integrated systems and information processing systems p0166 N73 21882
- NEWBERRY, C. F.**  
The effect of active noise reduction on speech intelligibility in a reverberant room p0236 N73 23052  
Internal sound field characteristics of a reverberant room after active noise reduction p0134 N72 11733 [AGARD R 553] p0134 N72 11733
- NEWBERRY, R. R.**  
Man-machine integration p0285 N73 21888
- NEWSON, R. L.**  
Nitrogen oxides in aircraft engine exhaust p0114 N74 14115
- NICHOLS, K. G.**  
Computer aided analysis of a helicopter rotor in a wind tunnel p0182 N74 12925
- NICHOLSON, A. N.**  
Use of hypothesis by microwave operational radar as a tool and experimental studies p0030 N73 21433  
Use of hypothesis by microwave operational radar as a technique for the evaluation of performance differences related to the flying task p0082 N73 21129
- NIELSEN, J. N.**  
A calculative method for predicting glider separation trajectories at speeds up to the critical speed p0035 N71 19379
- NIELSEN, D. L.**  
Acoustic weapon effects on the biosphere during disturbances p0140 N73 14169  
The effects of nuclear burst produced acoustic gravity waves on HF communication systems p0140 N73 14170
- NIELSON, K. A.**  
Pattern recognition using dynamic pattern information p0155 N72 11206
- NIJUSING, R.**  
Heat exchange and heat exchangers with liquid metals p0299 N72 18948
- NILSSON, L.**  
Beyond the horizon propagation over sea at 170 MHz 5000 MHz p0116 N71 21429  
Variations in radio waves due to tropospheric effects at frequencies between 180 MHz and 3 GHz in the vicinity of the horizon p0146 N73 13862  
The propagation of very high frequency signals over the horizon p0146 N73 13862  
The propagation of very high frequency signals over the horizon p0146 N73 13862
- NINOW, E. H.**  
Psychophysical quality factors in tasks affecting discrimination of navigation aids p0211 N72 20713
- NIVEN, J. I.**  
Orientation of aircrews in Army aviation aircraft p0071 N72 25174
- NOBLE, H. V.**  
Model equations for aerospace systems p0117 N72 19484
- NOGUES, C.**  
Some observations on the difficulty of this method evaluation and its related factors p0075 N72 26049  
Value of cardiac mechanisms in evaluating a flight personnel p0085 N74 13711
- NOLL, R. B.**  
Analysis of terminal ATC system operations p0233 N73 23700
- NORBERT, T. J.**  
Fatigue behavior of laminated composites in flight p0211 N73 27497
- NORMAN, L. W.**  
Advanced turbine auxiliary power system p0065 N73 19645
- NORRIS, D. H.**  
Application of finite element methods in fluid dynamics p0182 N72 27375
- NORTH, J. F.**  
The measurement and interpretation of the effects of hypoxia p0131 N72 19110
- NOVAK, S. R.**  
Some aspects of the effects of the hypoxia of space environments on the flight methods [NASA TM X 68371] p0286 N72 21965
- NOVAKOV, T.**  
Some aspects of the effects of the hypoxia of space environments on the flight methods p0221 N74 14219
- NURZIA, F.**  
The effects of the hypoxia of space environments on the flight methods p0286 N72 21965
- NYBERG, S. E.**  
The effects of the hypoxia of space environments on the flight methods p0286 N72 21965
- NYE, J. L.**  
Effects of the hypoxia of space environments on the flight methods p0286 N72 21965
- NYGARD, K.**  
The effects of the hypoxia of space environments on the flight methods p0286 N72 21965
- OCH, F.**  
Application of composite materials for aerospace structures p0211 N72 21482
- O'CONNOR, P. J.**  
Psychiatric casualties among airmen of the Royal Air Force of Great Britain for the year 1959 p0095 N72 14110  
Clinical evaluation and treatment of dysmetria in airmen p0080 N72 21509  
Clinical psychology and psychiatry of the aerospace operational environment p0089 N74 18779  
Results of behavior therapy p0089 N74 18782  
Depression in airmen p0089 N74 18784
- OESTREICHER, D. R.**  
Parallel printed circuit board design system p0168 N74 13936
- OETTL, H.**  
Directional antenna for a new interferometer system for the suppression of phase character in a suppression of space interferences p0134 N73 10213
- OFFERINS, R. P.**  
Optimum control of a helicopter in a wind tunnel p0233 N73 23700
- OKAPUU, U.**  
An experimental wind tunnel study p0259 N71 1381
- OLEARY, G. C.**  
A method for determining the form of the form of the form p0130 N73 10198
- OLESEN, J. K.**  
On the stability of the form of the form of the form p0130 N73 10198
- OLIVER, R. B.**  
Application of the form of the form of the form p0130 N73 10198
- OLSEN, J. J.**  
Application of the form of the form of the form p0130 N73 10198
- OLSEN, R. L.**  
Application of the form of the form of the form p0130 N73 10198
- OLSSON, S.**  
On the effects of the form of the form of the form p0130 N73 10198
- OMAN, C. M.**  
Automated system analysis p0130 N74 20751
- OMMAYA, A. K.**  
Protective effects of the form of the form of the form p0130 N74 20751
- OPPENHEIM, A. K.**  
Effects of the form of the form of the form p0130 N74 20751
- ORAZIO, F. D.**  
Physical properties of a fluid volume p0130 N74 20751
- ORD, J. W.**  
The effects of the form of the form of the form p0130 N74 20751
- ORMISTON, R. A.**  
A method for the form of the form of the form p0130 N74 20751
- ORR, D. G.**  
The effects of the form of the form of the form p0130 N74 20751
- OSBORNE, J.**  
The effects of the form of the form of the form p0130 N74 20751
- OSMAH, C.**  
The effects of the form of the form of the form p0130 N74 20751
- OVERINGTON, I.**  
The effects of the form of the form of the form p0130 N74 20751
- OWEN, W. S.**  
The effects of the form of the form of the form p0130 N74 20751
- OWSON, C. N.**  
The effects of the form of the form of the form p0130 N74 20751
- OXX, G. D., JR.**  
The effects of the form of the form of the form p0130 N74 20751



## P

## PABLOT, J.

Linear and nonlinear characteristics of a unidirectional epoxy-silicon reinforced composite p0207 N72 12496

## PABST, D.

Programmable PCM telemetry encoder for space applications p0193 N72 19504

## PAGE, H.

The propagation of electromagnetic waves over irregular terrain p0146 N74 13948

## PAGE, R. A.

Range and radius of action performance prediction for transport and combat aircraft p0052 N73 24043

## PAGNI, P. J.

Smoke suppressant additive effects on particulate emissions from gas turbine combustors p0221 N74 14299

## PALFREMAN, S. J.

The state of the art of small gas turbine engines for helicopters and surface transport p0282 N71 26953

## PALMER, W. T.

Aerospace computer input/output techniques p0156 N72 21219

## PALO, E. A.

A flexible hardware fast Fourier transform digital processor p0132 N73 10198

## PALUMBO, B.

Three-axis R.F. attitude sensor of a geostationary satellite p0191 N72 19492

## PANKHURST, R. C.

Facilities and techniques for aerodynamic testing at transonic speeds and high Reynolds numbers p0172 N72 12162

## [AGARD AR 37 71]

Latest technology in aerodynamic measurements p0199 N72 25433

## [AGARD US 49]

Technical evaluation report on Fluid Dynamics Panel Specialists Meeting on Fluid Dynamics of Aircraft Stalling [AGARD AR 49] p0046 N73 18023

## PANNIER, R.

Antidiabetic medications and navigation personnel p0082 N73 21320

## [AGARD AR 37 71]

Asplenia in military flying personnel p0085 N74 13792

## [AGARD AR 37 71]

Idiopathic spontaneous pneumothorax in flying personnel p0085 N74 13793

## PAOLUCCI, G.

Behaviour of some serum enzyme activities in man after crash accidents causing massive injuries p0101 N72 19138

## [AGARD AR 37 71]

In-flight psychological studies in student pilots evaluated by means of Wand-Mantel-Aid (VMA) changes in urinary excretion p0089 N74 18790

## PARALIOU, K. D.

On the two-dimensional boundary layers as they appear on turbomachine blades p0268 N73 19195

## PARIRIO, R.

Determination of matrix and filament stress-strain properties from tests on carbon composites p0207 N72 12500

## PARABONI, A.

Depolarization of an electromagnetic wave traveling through a stratified aerosol in the atmosphere p0140 N73 26123

## PARADE, P.

Drug use and performance p0981 N73 21115

## PARDAENS, J.

Selection of student pilot candidates of the Belgian Air Force by psychomotor tests p0988 N74 18788

## PARETTI, G.

Role of simulations in the study and development of the CROTALE system p0237 N74 14355

## PARK, S. K.

An analytic study of near terminal area optimal sequencing and flow control techniques p0233 N73 23701

## PARKER, D. E.

Effects of sound on the vestibular system p0109 N74 20745

## PARKER, G. R.

Aircraft fueling operations and quality control p0252 N72 11678

## PARKER, J.

Relative aircraft emission from an airport in the UK and neighbouring urban areas p0271 N73 24788

## [AGARD AR 37 71]

Relative aircraft emissions from an airport in the UK and neighbouring urban areas p0218 N74 14282

## PARKER, J. F. JR.

Use of special analysis procedures for the evaluation of drug effects p0181 N73 21116

## PARKER, J. H. JR.

Superconducting electrical machine p0187 N73 19149

## PARKER, R. L.

Application of dual scatter laser Doppler velocimeters for wind tunnel measurements p0200 N72 25596

## PAIKES, K. R.

The effects of brief hypoxia on cognitive performance p0304 N73 19372

## PARKINS, R. M.

Stress in aircraft test methods - The European Federation of Airframe Manufacturers p0285 N72 21954

## PARKINSON, R. C.

High speed jet engines p0299 N72 12156

## [AGARD AG 148 71]

High speed jet engines p0299 N72 12156

## PARRY, P. J.

Can fuel ash corrosion by vanadium be combated by alloying or coating without the use of fuel additives? p0203 N73 23613

## PARSONS, J. L.

A solution to the problem of mid-air collisions p0235 N73 23712

## PASINI, S.

An experimental research on the behavior of a continuous flow combustion chamber p0220 N74 14298

## PASK, J. A.

Nature, status and selection of ceramic materials p0205 N71 27041

## PATE, D. N.

Statistics on earth satellite attenuation at two Texas locations p0142 N73 26141

## PATTERSON, J. H.

A survey of drag prediction techniques applicable to subsonic and transonic aircraft design p0019 N74 14711

## PAULON, J.

Theoretical and experimental study of the coexistence of two types of flow in a channel with constant cross section p0267 N72 16716

## [AGARD AR 37 71]

Influence of type of attack and deflection on boundary layer flow in upright cascade blades p0269 N72 19803

## PATEUR, O.

All-weather Sud-Lez landing system installed on the Caravelle p0030 N71 23429

## PCAKE, D. J.

The half cone pressure field and its significance to side-mounted intakes p0003 N71 19167

## [AGARD AR 37 71]

Technical evaluation report on AGARD Specialists Meeting on Aerodynamic Interference p0010 N71 31459

## [AGARD AR 37 71]

The transonic performance of two-dimensional jet flapped airfoils at high Reynolds numbers p0012 N72 11851

## [AGARD AR 37 71]

Comparisons between some high Reynolds number turbulent boundary layer experiments at Mach 4 and various recent calculation procedures p0177 N72 20289

## [AGARD AR 37 71]

The drag resulting from three-dimensional separations caused by boundary layer disinters and nacelles in subsonic and supersonic flow p0021 N74 14728

## PEARCEY, H. H.

A type of stall with leading edge transonic flow and rear separation p0011 N72 11858

## [AGARD AR 37 71]

The derivation and verification of a new rotor profile on the basis of flow phenomena - aerofol research and flight tests p0051 N73 21647

## PEARSON, K. L.

Aerospace computer memory techniques p0156 N72 21218

## PECKHAM, C. G.

A summary of atmospheric turbulence recorded by NATO aircraft [AGA J. R. 586 71] p0217 N72 11511

## [AGARD AR 37 71]

Optimal joint positions for space trusses p0297 N74 15608

## PELAGATTI, C.

Methods of utilizing the results of flight tests for the study of flight performance of the Concorde's personal transport p0034 N72 20978

## PENNAACCHIONI, M. B.

Dynamic data processing systems p0195 N73 10454

## PENNER, S. S.

Technical evaluation report on the AGARD Propulsion and Energetics Panel 34th Meeting p0010 N71 31459

## [AGARD AR 37 71]

Reactions between Gases and Solids p0261 N71 19172

## PERDRIEL, G.

Interest in measuring resistance to vibration among flying personnel p0074 N72 25059

## [AGARD AR 37 71]

Examination of chemical sense in French pilots p0072 N73 19048

## [AGARD AR 37 71]

Ophthalmology and vision of pilots p0096 N74 13798

## PERONA, G. E.

Observations of gravity waves in the flight logs p0137 N73 14153

## PERRY, B. III.

The effect of horizontal tail loads and associated aircraft response on an autopilot for the Bell transport flying in turbulence p0039 N74 17742

## PERRY, C. J. G.

Characteristics of the stress-strain properties of military aircraft p0088 N74 18197

## PERRY, I. C.

Experimental study of terrain effects p0182 N72 25315

## [AGARD AG 159]

Atmospheric flying and navigation p0078 N71 19175

## PESMAN, G. J.

Acceleration in the design of aircraft p0034 N71 23338

## PETERS, C. E.

A review of the effects of hypoxia on human performance p0183 N71 17743

## PETERSON, J. M.

P. 4 - a new test MU technology for aircraft design p0278 N73 20979

## PETERSON, W. O.

Laboratory evaluation of aircraft p0156 N74 14219

## [AGARD AR 37 71]

Laboratory evaluation of aircraft p0156 N74 14219

## PETTIT, F. B.

On the effects of oxide dispersions and rare earth type elements on the oxidation of Cr and Al containing alloys p0202 N73 23608

## PFENNIGSTORF, J.

Evaluation of a integrated flight display for the manual IFR landing of VTOL aircraft p0224 N72 22631

## PFISTER, A. M.

Aeronautical factors and toothache incidences during flight p0092 N71 22309

## [AGARD CP 95 PT 3]

Special biophysical problems in aerospace medicine part 3 p0075 N72 26045

## [AGARD CP 95 PT 3]

First results of passive asymmetric compensation effects onboard a prototype of the Concorde 201 supersonic transport p0075 N72 26052

## PHATAK, A. V.

Current status of models for the human operator as a controller and decision maker in manned aerospace systems p0205 N73 23897

## PHELPS, A. D. R.

The polar exospheric plasma p0126 N72 21124

## PHELPS, E. M.

Microscopic identification of stress corrosion cracking in steels with high yield strength p0289 N72 21925

## PHILIPPE, J. J.

Aerodynamic forces computation and measurement of an oscillating aerofol profile with and without stall p0050 N73 21042

## PHILLIPS, E. J.

Assessment of wind test techniques p0294 N73 29922

## PHILLIPS, F. C.

Testing and evaluation of the Canadian CC-84 military V-STOL aircraft p0053 N73 27007

## PIALOUX, P.

A proposed habituation labyrinth presentation of several results with the P.N.T. p0108 N74 20737

## PIANKO, M.

Modern Methods of Testing Rotating Components of Turbomachines [AGARD AG 167] p0271 N73 26800

## PIATTELLI, M.

Determination of an optimal trajectory in the presence of noise p0279 N73 23886

## PICHEL, W.

Factors affecting the accuracy of sea surface temperature measurements from HTOS SR data p0124 N72 16107

## PICKNETT, R. G.

Ground contamination by fuel jettisoned from aircraft p0116 N74 14283

## PIENING, M.

Propagation Effects in monitoring atmospheric low structure using side scatter on appropriate frequencies p0122 N72 16097

## PIERCE, A. D.

A model for acoustic gravity wave excitation by gravity, rising and oscillating air masses p0134 N71 14135

## [AGARD AR 37 71]

Explosive oxidation of Lamps atmospheric edge mode p0126 N73 4143

## [AGARD AR 37 71]

Generation of anomalous atmospheric oscillations by the ionosphere p0136 N73 14148

## PIERCE, G. A.

A comprehensive steady theory for helicopter rotors p0053 N73 21044

## PIKE, C. P.

A discussion of Aircraft Diagrams p0126 N72 21125

## PIKE, E. C.

Manual for aerodynamic stability, buffet, and author index [AGARD R 578 71] p0001 N71 14132

## PINET, J.

Control of aircraft p0127 N71 16066

## PINGANAU, P. M.

Statistical analysis of reliability of flight personnel in the French Air Force p0096 N72 14098

## PINSKER, W. J. G.

The flight theory and calculations in the refinement of flying qualities p0044 N71 16999

## PIPER, D. E.

Summary and evaluation of subsonic wing-body stresses on the Concorde p0292 N72 18937

## [AGARD AR 52]

Summary and evaluation of subsonic wing-body stresses on the Concorde p0292 N72 18937

## PITMAN, D. L.

Aircraft solutions for aircraft design p0226 N72 27684

## [AGARD AR 52]

Optimization p0226 N72 27684

## [AGARD AR 52]

Kalman filter p0226 N72 27686

## PLANET, H.

Experimental study of natural convection radiation in building systems p0075 N72 26052

## PLAS, F.

Thermal effects of atmospheric reentry on aircraft p0093 N73 22118

## POISSON, QUINTON P.

Airframe and engine systems p0025 N71 26054

## [AGARD AR 37 71]

Wind tunnel test facilities for aircraft p0015 N72 14132

## [AGARD AR 37 71]

Wind tunnel test facilities for aircraft p0015 N72 14132

## POISSON, QUINTON PH.

A summary of wind tunnel test facilities for aircraft p0015 N72 14132

## POLLOCK, S. J.

Application of FFT to aircraft vibration analysis p0015 N72 14132

## R

## POOL A

- AGARD flight test instrumentation series: Volume 2  
in flight temperature measurements  
[AGARD AG 160 VOL 2] p0196 N73 20499
- AGARD flight test instrumentation series: Volume 4: The  
measurement of engine rotation speed  
[AGARD AG 180 VOL 4] p0196 N74 14116
- POPE G G  
Structural design applications of mathematical program-  
ming techniques  
[AGARD AG 149 71] p0283 N71 20128
- Introduction and basic concepts p0283 N71 20129
- Classical optimization theory relevant to the design of  
aerospace structures p0283 N71 20131
- Sequence of linear programs p0283 N71 20133
- Computer programs for the optimum design of complex  
elastic structures p0284 N71 20136
- POSEY J W  
Explosive excitation of Lamb's atmospheric edge mode  
p0136 N73 14143

## POTER, G

- Performance measurement using pilot controlled G2  
maneuvering with simulated operational task  
[AMRL TR 72 3] p0106 N73 19154

## POURBAIX, M

- What are the advantages and limitations in the use of  
equilibrium thermodynamics for the treatment of complex  
high temperature corrosion reactions? p0201 N73 23602

## PRAGER, W

- Optimality criteria in structural design  
[AGARD H 589 71] p0034 N72 15958
- Necessary and sufficient conditions for global structural  
optimality p0295 N74 15597

## PRATT, K G

- Theoretical horizontal tail loads and associated aircraft  
responses of an autopilot controlled jet transport flying in  
turbulence p0059 N74 17742

## PRECHTER, R

- Effusion cooling of turbine blades  
Aerodynamics of thrust reverser design p0264 N72 16695

## PREMELAAR, S J

- Main machine considerations in the development of a  
cruiser for an advanced tactical fighter p0281 N73 23905

## PREST, A M

- Current progress in the collaborative testing programme  
of the stress corrosion cracking fracture mechanics working  
group p0260 N72 21905

## PRESTON, F S

- Aspects of sleep regulation in airline pilots  
p0180 N73 21007

## PRIDE, R A

- Application of composites to the selective reinforcement  
of metallic aerospace structures p0211 N73 27485

## PRIEST, A M

- Factors influencing threshold stress intensity values and  
crack propagation rates during stress corrosion cracking  
tests of high strength steels p0287 N72 21913

## PRIEUR, L

- Brief on the theories of radiative transfer applicable to  
propagation in the sea p0241 N73 33622

## PROST, G

- Energy storage and discharge by superconductors  
p0064 N73 19043

## PRUEMPER, H

- Application of boundary layer fences in turbomachinery  
p0270 N73 19810

## PRUNET FOC4, B

- Theoretical and experimental research of free surface flow  
information of boat hullage p0041 N73 15901

## PUGH, P G

- The drag of externally carried stores: its prediction and  
allowance p0021 N74 14729
- The development of an efficient and economical system  
for the generation of jet transport flow suitable for model  
testing in high Reynolds number p0174 N74 16390

## PYLE, J S

- Review of drag measurement in high speed wind tunnel  
and aircraft with comparison to wind tunnel prediction  
p0022 N74 14735

## Q

## QUEMARD, C

- Application of an improved finite element method to the  
study of three dimensional boundary layers p0277 N72 20284

## QUICK, J R

- Project Split: Remote sensing using microwave remote  
sensing p0121 N72 16787

## QUIGLEY, R E JR

- Technical evaluation report on 1990 Propulsion and  
Power System Meeting on Propulsion for Aircraft Auxiliary  
Power Systems [AGARD AR 59] p0063 N73 18983
- Qualitative analysis power and fuel for high Mach aircraft  
p0065 N73 19048

## QUILLEVERE, A

- Maximal power of wave in the effect of low frequency  
water circulation p0225 N74 14727

## RAAB, H W

- A summary of human tolerance to prolonged acceleration  
p0094 N71 23341

## RADCLIFFE, F A

- Psychophysiological and environmental factors affecting  
disorientations in naval aircraft accidents p0071 N72 25036

## RADE, M

- Influence of turbulence on helicopter design and opera-  
tion p0059 N74 17736

## RADERMACHER, K

- Propagation characteristics of tropospheric scatter radio  
waves in the 5 GHz range with respect to path loss predic-  
tions p0120 N71 23469

## RAEMER, H R

- An approach to the analysis of coupling between  
acoustic gravity waves and electromagnetic waves  
p0138 N74 14162

## RAETHJEN, P

- The structure and dynamics of the troposphere  
p0114 N71 21411

## RAINBIRD, W J

- The half cone pressure field and its significance to side  
mounted intakes p0003 N71 19367
- Tables of inviscid supersonic flow about circular cones  
at incidence gamma equals 14 part 3  
[AGARD GRAPH 137 PT 3] p0175 N72 15269
- The drag resulting from three dimensional separations  
caused by boundary layer diverters and nacelles in subsonic  
and supersonic flow p0021 N74 14728

## RAINEY, A G

- Active control of aeroelastic response  
p0045 N72 17005

## RAMEY, C M

- Main machine combination in the light of safety require-  
ments p0029 N73 23423

## RANDLE, R J

- Volitional control of visual accommodation  
[NASA TM X 66955] p0070 N71 20371

## RANZI, E

- An important characteristic of some traveling tropospheric  
disturbances p0139 N73 14156
- Propagation effects of frequency sharing  
[AGARD CP 127] p0145 N74 13846
- Tropospheric influence on the screening effect due to a  
medium ridge in 2 GHz p0146 N74 13853

## RAO, G L

- Tropospheric disturbances caused by long period sound  
waves generated by Saturn A and launches p0138 N73 14157

## RAPP, R A

- Vaporization losses from CO2 protective states  
p0202 N73 23607

## RAPPAILLIER, G

- Propagation characteristics of tropospheric scatter radio  
waves in the 5 GHz range with respect to path loss predic-  
tions p0120 N71 23469

## RABMUSSEN, H I

- High Reynolds number testing by means of rocket  
stems p0016 N72 11895

## RAUDSEPS, J G

- Automatic detection of vehicle in aerial photographs  
of highways p0152 N72 11183

## RAVIART, B

- Value of aerodynamic mechanical parameters evaluated during  
penetration p0089 N74 13791

## RAY, E J

- Maneuver and buffer chart for shock of type aircraft  
p0043 N73 15019

## RAYNE, J M

- Shock heating effects on low speed flow in reacting air  
account of a new theoretical test facility p0102 N72 19147

## READ, B E

- Experimental methods for composite materials  
p0209 N71 29533

## READER, R C

- A case for the negative of drag p0114 N72 19158

## REASON, J T

- Factors contributing to the occurrence of hypoxia  
Atmospheric and medical p0078 N73 25000

## REBOUT, J

- Aerodynamic effects of a large wing planform with open  
flaps in steady and unsteady flow p0040 N71 21043

## REDDY, K G

- Theory of aerodynamic flow over a flat plate in a  
compressible flow p0021 N73 19170

## REDDY, R

- Computational modeling of aircraft systems: Some selected  
examples p0162 N72 11196

## REDEPER, G

- A review of the state of the art in buffer flow  
controlling the influence of Reynolds number p0011 N72 11897

## REESE, R A

- High speed plasma jet engine: Theory and experimental  
results p0061 N71 19014

## REEVES, B L

- A review of the state of the art in buffer flow  
controlling the influence of Reynolds number p0011 N72 11897

## REICHERT, G

- Influence of elastic coupling effects on the handling  
qualities of a hingeless rotor helicopter p0047 N73 21016

- Some aspects of the design of rotor airfoil shapes  
p0051 N73 21045

- Basic dynamics of rotors: control and stability of rotary  
wing aircraft aerodynamics and dynamics of advanced  
rotary wing configurations p0017 N73 22951

- Loads prediction methods for hingeless rotor helicop-  
ters p0056 N74 10915

- Influence of turbulence on helicopter design and opera-  
tion p0059 N74 17736

## REINHARDT, M

- AGARD flight test instrumentation series: Volume 2  
in flight temperature measurements [AGARD AG 160 VOL 2] p0196 N73 20499

## REINHART, T J, JR

- Mechanical properties of high performance plastic  
composites p0210 N73 27475

## REINDEHL, J E

- The use of slow strain rate experiments in evaluating  
resistance to environmental cracking p0289 N72 21927

## RENAUD, A

- Ten years experience with the helicopter from operation  
in French Army p0046 N73 21011

## RENAUDIE, J F

- Some aspects of flight measurements and calculations  
p0035 N72 20984

- Amplification effects from a flight mechanics standpoint  
p0044 N73 16991

## RENFLE, G

- The problem of diabetes mellitus in aviation medicine  
p0087 N74 13804

## RENO, V R

- Magnetic fields and man: Where do we stand today?  
[NASA CR 327049] p0076 N72 26055

## REPLUGUE, C R

- Analysis of the vestibulo-ocular counterroll reflex in  
primates [AMRL TR 71 59] p0072 N72 15047

- Performance measurement of flying pilot controlled by  
maneuvering with simulated operational task  
[AMRL TR 72 3] p0106 N73 19154

## RESCHKE, M F

- Effect of visual input on the vestibular system  
p0109 N74 20745

## RESS, E

- Some novel methods in failure analysis  
p0191 N72 19488

## RESS, G

- Some novel methods in failure analysis  
p0191 N72 19488

## RESTALL, J E

- The environment encountered by high speed aircraft  
components of the aircraft gas turbine p0201 N73 23599

## REVAH, I

- One way of gravity waves in the ionosphere system  
by means of meteor trail detection p0174 N74 16394

## REYN, J W

- Roll and drag characteristics of delta wing half cone  
and profiles with extreme leading edges using slender  
body theory p0003 N72 11895

## REYNAUD, F

- Theoretical study of a theoretical propeller system  
lubricating oil p0254 N72 11699

## REYNOLDS, M L

- Methods of identification of the earth's magnetic field  
examples of application to atmospheric determination of  
spacecraft p0192 N72 19495

## REYNOLDS, R A

- High temperature fuel cells  
[NASA TM X 67123] p0261 N73 22699

## RHODES, W W

- Configurations of aircraft components stabilized in  
supersonic transports p0001 N71 19373

## RHODES, A N

- Some of the effects of the intake and fatigue in the  
flexing of a shaft p0050 N74 19653

## RHODES, R G

- The behavior of a propeller system in the presence of  
side wind effects p0061 N73 19373

## PICARDI, L J

- A simple model for the prediction of a system  
p0193 N72 19507

## RICCIUS, R

- VAF 191 B experimental program for a V-101 engine  
Reconnaissance p0054 N72 21006

## RICE, P L

- Propulsion and aerodynamics of a hypersonic vehicle  
p0021 N72 11895

## RICHARDS, O M

- Propulsion and aerodynamics of a hypersonic vehicle  
p0021 N72 11895

## RICHARDSON, H M

- Propulsion and aerodynamics of a hypersonic vehicle  
p0021 N72 11895

## RICHARDSON, J M

- Some adaptive approaches to pattern recognition  
p0154 N72 11895

## RICHARZ, O

- VAF 191 B experimental program for a V-101 engine  
Reconnaissance p0054 N72 21006

## RICHENS, J

- VAF 191 B experimental program for a V-101 engine  
Reconnaissance p0054 N72 21006

## RICHMOND, D R

- The theory of the hypersonic flow

**RICHTER, J. H.**  
Remote sensing of tropospheric structures using high resolution radar. p0123 N72 16101  
FM CW radar studies of production of turbulent instability within thermally stable layers by internal waves. p0137 N73 14151

**RICKETSON, D. S.**  
Incidence, cost and factor analysis of pilot error accidents in US Army aviation. p0107 N74 18804

**RIDER, J. D.**  
Radio Wave diffraction due to a mountain of volcanic origin. p0146 N74 13851

**RILEY, M. J.**  
The derivation and verification of a new rotor profile on the basis of flow phenomena: aerofol research and flight tests. p0051 N73 21047

**RINGO, R. L.**  
The evolution of ESG technology. p0229 N73 20698

**RIPOLL, J.**  
Test methods and examples from the Propulsion Test Center. p0283 N72 16890

**RITMAN, E. L.**  
Effects of positive G<sub>y</sub> acceleration on blood oxygen saturation and pleural pressure relationships in dogs breathing first air then liquid fluorocarbon in a whole body water immersion respirator [NASA CR 117199]. p0068 N71 20358

**RIZZO, V.**  
Scanning radiometers for meteorological satellite. p0192 N72 19497

**ROBERTS, G. H.**  
Relative air pollution emission from an airport in the UK and neighbouring urban areas. p0271 N73 24788  
Relative air pollution emissions from an airport in the UK and neighbouring urban areas. p0218 N74 14282

**ROBERTS, R.**  
Development and verification of an analytical model for predicting emissions from gas turbine engine combustors during low power operation. p0220 N74 14295

**ROBERTS, S. C.**  
The handling quality required for safe operation of single engine boundary layer controlled aircraft in the STOL mode. p0028 N71 23419

**ROBERTS, V. L.**  
Biomechanics of restraint and impact attenuation systems. p0103 N72 19156  
The biomechanical aspects of crash helmet design. p0104 N72 19161

**ROBINS, J. E.**  
Evaluation of the role of the simulator in training airborne ASW operators. p0107 N74 18801

**ROBINSON, S. J.**  
Design and evaluation of a helicopter guidance aid. p0034 N72 11936

**ROBSON, R.**  
Stability of synthetic aviation gas turbine fuels at high temperatures. p0254 N72 11635

**ROCARD, Y.**  
The theory of atmospheric acoustic propagation. p0138 N73 14142

**RODDEN, W. P.**  
New developments and applications of the submic double lattice method for planar configurations. p0008 N71 29340

**RODRICK, T. L.**  
Computers for satellite based navigation and guidance systems. p0157 N72 21276

**ROEPER, Y. J.**  
A special interest documentation center: its organization, its methods, its effectiveness. p0113 N71 19529

**ROESNER, R. O.**  
Numerical treatment of time dependent three dimensional flows. p0122 N72 21307

**ROETTER, J.**  
An application of the Monte Carlo method to remote sensing systems. p0125 N72 16115  
Some effects of atmospheric gravity waves observed on a trans-equatorial radar path. p0139 N73 14164

**ROGAN, J. E.**  
Ablation [AGARD AG 161]. p0299 N72 24959

**ROGERS, D. B.**  
Performance measurement using pilot questionnaires for maneuvering with simulated operational task. [AMRL TR 72-3]. p0106 N73 13154

**ROGERS, L. W.**  
Recent experience in the transonic testing of two dimensional swept and straight wings with high lift devices. p0012 N72 11860

**ROGERS, R. R.**  
Application of weather radar data to propagation predictions. p0114 N73 21416

**ROLFE, J. M.**  
The application of pressure optimization to pilot tasks and equipment to flight safety research. p0197 N74 18892

**ROLLINS, J. W.**  
Results of behavior therapy in flying clubs. p0088 N74 18182  
Depression in aircrew. p0088 N74 18184

**ROLSTEN, R. F.**  
Armor materials for life support. p0102 N72 19143

**ROMESKIE, J. M.**  
Comparisons between time light Rayleigh scatterer induced laser Doppler velocimetry at M1.4 and a type lock velocimetry probe. p0172 N72 20289

**ROONEY, E. C.**  
Development of techniques to measure in flight drag of a US Navy fighter airplane and correlation of flight measured drag with wind tunnel data. p0022 N74 14734

**ROQUES, S.**  
What are the prospects for the successful application of coated refractory metals in uncooled turbines? p0203 N73 23614

**ROSEN, B. W.**  
Composite materials [AGARD US 55]. p0209 N72 29589

**ROSEN, W.**  
Design of composite materials. p0209 N72 29590

**ROSENBAUM, R. H.**  
VHF propagation measurements on mixed diffraction scatter paths. p0117 N73 21431

**ROSENFELD, A. P.**  
Some recent developments in fatigue and fracture. p0204 N74 23110

**ROSHKO, A.**  
The effect of density difference on the turbulent mixing layer. p0112 N72 20295

**ROSIEN, R. A.**  
The performance of the Doppler microwave landing system in a multipath environment. p0234 N73 23706

**ROSENER, D. E.**  
Environmental effects on gas metal reactions at elevated temperatures. p0112 N73 23606

**ROSS, M. A. S.**  
Numerical treatment of fluid dynamical stability problems. p0185 N74 22921

**ROTA, P.**  
Experimental research on heat balance of athletes of various specialties during muscular exercise in different thermal environments. p0070 N71 20366  
Study on some air force operational activities in Italy with reference to thermal conditions and their effects on acceleration tolerance and psychomotor performance. p0084 N73 23068

**ROTHMAN, N. N.**  
Evaluation, development and advantages of the heaving tandem dual cargo hook system. p0048 N73 21022

**ROTONDO, G.**  
Statistical survey of the clinical causes of temporary grounding and permanent unfitness of IAF aircrews. p0095 N72 14091

**ROTTA, J. C.**  
Recent attempts to develop a generally applicable correlation method for turbulent shear flow layers. p0179 N72 20298

**ROTVEL, F.**  
On residual stresses during random load fatigue. p0291 N73 16972

**RUBIN, W.**  
Clinical application of splanchnography. p0108 N74 20713

**RUBNER, K.**  
Annulus wall boundary layers in axial flow turbomachinery. p0270 N73 19814

**RUECKER, F.**  
Measurements of precipitation scatter at 11.6 GHz. p0147 N74 13855

**RUGGLES, R.**  
Developments in aircraft digital systems. p0281 N73 23990

**RUHLIN, C. L.**  
Active control of anelastic response. p0045 N73 17095

**RUNKEL, J. F.**  
Aerodynamic interference between exhaust systems of aircraft. [NASA TM X 66888]. p0093 N71 19368

**RUEBEL, R. A. JR.**  
Coxsack safe surface fuel development by the Federal Aviation Administration, 1964-1970. p0253 N72 11697

**RUSSELL, C.**  
Model testing requirements and techniques for high lift schemes: Three dimensional aspects. p0026 N71 20057

**RYAN, T. G.**  
Evaluation of the role of the simulator in training airborne ASW operators. p0107 N74 18891

**RYDER, D. A.**  
The elements of topography [AGARD AG 155-71]. p0285 N72 13992

S

The blunt body problem for a viscous rarefied gas flow. p0182 N72 27303

**SALLADA, R. V.**  
US naval test pilot training. p0037 N72 20996

**SALTZMAN, E. J.**  
A comparison of some of dynamic drag factors as determined in full scale flight with wind tunnel and theoretical results. p0013 N72 11869  
Review of drag measurements from flight tests of manned aircraft with comparisons to wind tunnel predictions. p0022 N74 14735

**SALVAGE, J. W.**  
Secondary flow research at the von Karman Institute. p0270 N73 19811

**SALVAGNIAC, J.**  
Tracing of arteriosclerosis during evaluation of flying personnel. p0093 N71 22318

**SANDERS, L. L.**  
The performance of the Doppler microwave landing system in a multipath environment. p0234 N73 23706

**SANDFORD, M. C.**  
Active control of aeroelastic response. p0015 N73 17005

**SANDNESS, G. A.**  
Effect of beam width on acoustic signals scattered at a rough surface. p0123 N72 16102

**SANDOVER, J.**  
Measurement of human responses during impact. p0102 N72 19145

**SAPUPPO, M. S.**  
Strapdown inertial gyroscope. p0228 N73 20688

**SARAIVA MENDES, J. A.**  
Analysis of 11 GHz band propagation in Portugal. p0148 N74 13869

**SARLES, F. W. JR.**  
The use of visible light sensors in spinning satellite control systems. p0192 N72 19500

**SASS, D. J.**  
Effects of positive G<sub>y</sub> acceleration on blood oxygen saturation and pleural pressure relationships in dogs breathing first air then liquid fluorocarbon in a whole body water immersion respirator [NASA CP 117109]. p0068 N71 20358

**SATTA, A.**  
On the two dimensional boundary layers as they appear on turbomachine blades. p0268 N73 19795

**SATTIN, M.**  
Elastic constants evaluation of a reinforced plastic material. p0207 N72 12497

**SAUTTER, M. E.**  
A model of the system for small users. p0160 N74 16935

**SAWYER, R. F.**  
Flame inhibition chemistry. p0252 N72 11680  
Atmospheric pollution by aircraft engines and fuels: a survey. p0217 N72 21590  
Factors controlling pollutant emissions from gas turbine engines. p0220 N74 14292

**SAWYER, W. Q.**  
Some boundary layer measurements on a flat plate at Mach numbers from 2.5 to 4.5. p0177 N72 20288

**SCANO, A.**  
Biodynamics facilities in NATO European countries. p0095 N71 23343

**SCHAEKEL, F. W.**  
Engine fuel and aircraft safety. p0253 N72 11688

**SCHAEZNER, O.**  
The effect of gusts on two shear for automatic STOL approach and landing. p0058 N74 17730

**SCHAMBECK, W.**  
Circuit design for spacecraft with complementary MOS technology. p0191 N72 12496

**SCHAPHORET, R.**  
Phototransmission and video storage. p0159 N72 22172

**SCHAUB, U. W.**  
Flow distortion and performance measurements on a 12 inch fan wing model for a range of forward speeds and angle of attack settings. p0285 N72 16702

**SCHERER, H.**  
Thermoelectric stimulation of the labyrinth. p0109 N74 20748

**SCHIJVE, J.**  
The accumulation of fatigue damage in aircraft materials and structures. p0290 N72 22918  
The accumulation of fatigue damage in aircraft materials and structures. p0291 N73 16899  
Effects of test frequency on fatigue crack propagation under flight simulation loading. p0291 N73 16900  
Aspects of accelerated fatigue. p0294 N73 22925

**SCHIRRMANN, O.**  
German Air Force experiments with exhaust cooling for gas turbine engines. p0087 N74 13306

**SCHLEUSNER, S. A.**  
Ethanol layer propagation in a CO<sub>2</sub> atmosphere in the near-critical region. p0124 N72 16100

**SCHMID, H.**  
Solution for steady aircraft on multiple lifting surfaces. p0008 N71 29339

**SCHMIDT, K.**  
A method for automatic control system evaluation. p0224 N72 22629

- SCHMIDT, T. W.**  
Studies of aircraft flow fields at inlet locations  
[NASA TM X 66885] p0004 N71 19371
- SCHMIDTLEIN, H.**  
Operational proving of automatic flight control systems for V-STOL fighter aircraft p0028 N71 23415
- SCHMIT, L. A.**  
Structural design applications of mathematical programming techniques  
[AGARD AG 149 71] p0283 N71 20128  
Introduction and basic concepts p0283 N71 20129  
A basis for assessing the state of the art p0283 N71 20130  
Literature review and assessment of the present position p0283 N71 20132  
Special purpose applications p0284 N71 20137
- SCHMITT, H.**  
Optimization of automatic flight control concepts for light helicopters with all weather capability p0030 N72 11917
- SCHNEIDER, W.**  
Force and pressure measurements on a slender delta wing at transonic speeds and varying Reynolds numbers p0012 N72 11863
- SCHNIDERMAN, A. M.**  
Means remedies of the instantaneous spatial distribution of a passive scalar in an axisymmetric turbulent wake p0179 N72 20297
- SCHNELL, E.**  
Analysis of small gas turbine engine components p0262 N71 26955  
Auxiliary power units for secondary power systems p0065 N73 19046
- SCHOEDEL, J. P.**  
A phenomenological investigation of amplitudes and spectra of gravity waves p0137 N73 14149
- SCHOLNAUER, W.**  
An addy viscosity based on the second principal invariant of the deformation tensor p0176 N72 20260
- SCHOENBECK, A.**  
Effusion cooling of turbine blades p0258 N71 17382
- SCHOENBERGER, O. H.**  
Terrain avoidance radar for US Army p0032 N72 11977
- SCHOENMAN, R. L.**  
Fly by wire and artificial stabilization design p0045 N73 17009
- SCHOLTEN, C. O. H.**  
ATC environment present and future p0202 N73 22693
- SCHOLTEN, R.**  
Influence of the ground on the near field noise levels of jet supported V-STOL aircraft p0292 N73 29907
- SCHOLZ, R.**  
Effusion cooling of turbine blades p0258 N71 17382
- SCHROEDER, L. G.**  
Revisions to V-STOL handling qualities criteria of AGARD report 408 p0038 N72 32021  
Considerations for stability and control of V-STOL aircraft: A review of AGARD report 577 p0044 N73 16994
- SCHUBERT, R.**  
Fundamental subjects of gerontology and particularities of geriatrics p0292 N71 22112
- SCHUELER, C. J.**  
High Reynolds number transonic wind tunnels: Blow down or Ludwig tube? p0015 N72 11881
- SCHUETZ, W.**  
The fatigue life under three different load spectra: Tests and calculations p0291 N73 16903  
Technical evaluation report on the AGARD symposium on Fatigue Load Fatigue p0292 N73 28884  
Fatigue life prediction: A somewhat optimistic view of the problem p0295 N73 29934
- SCHULER, S. C.**  
Selective dissemination of information: A system review p0301 N71 23506  
Tailored abstracts and technical digests: A service for industry p0159 N73 24250
- SCHULTE WINTROP, H.**  
Transients and aviation p0082 N73 21521
- SCHULTZ, D. L.**  
Heat transfer measurements in short duration hypersonic facilities  
[AGARD AG 165] p0300 N72 20945
- SCHULTZ, D.**  
Optimization and design of the rear fuselage of the A-300-B aircraft structure p0298 N74 15614
- SCHURATH, U.**  
Photo degradation of aircraft engine emissions at low and high altitudes p0218 N74 14277
- SCHURINGA, T.**  
Aerodynamics of wing stall of the Fokker F28 p0343 N73 15115  
Adjustment of flying qualities by wind tunnel testing p0455 N73 17000
- SCHWARTZ, E.**  
The propulsion jet of a VTOL aircraft p0265 N72 16760
- SCHWARTZBACH, C.**  
An experimental investigation of curved two dimensional turbulent jets p0178 N72 20294
- SCHWEIKARDT, R. G.**  
Control concept for wind turbine testing of a personal intake control system p0266 N72 16766
- SCHWEIZER, G.**  
Trends towards standardized software and hardware for test systems p0236 N74 14351
- SCIBILLA, W. F.**  
Drag of lifting bodies for pilots at high altitude p0021 N74 14731
- SCOLATTI, C. A.**  
Progress of the USAF inflight program: Low speed control to landing on instrument in helicopters p0031 N72 11920
- SCOTLAND, R. L.**  
The effect of engine failure at supersonic speeds on a slender aircraft: Predicted and actual p0045 N73 17003
- SCOTT, E. M.**  
Developments in aircraft digital systems p0281 N73 23900
- SCOTT, G.**  
An evolving operational computer aided design system p0167 N74 13929
- SCOTT, E.**  
Military applications of research and development in tropospheric wave propagation p0114 N71 21410
- SCRIBNER, W. G.**  
Application of analytical techniques for the analysis of additives and contaminants in advanced hydrocarbon fuels p0251 N72 11673
- SCULLY, J. C.**  
The science committee conference on the theory of stress corrosion cracking of alloys p0283 N72 21707
- SEACORD, C. L.**  
Functional design of Microwave Landing System (MLS) airborne equipment as influenced by rigid equipment configuration and aircraft type p0234 N73 22765
- SEALE, S. J.**  
Some psychometrics in relation to target acquisition p0304 N73 19974
- SEAMANS, R. C.**  
The von Karman lecture: Lessons learned and future directions in the management of technical programs p0302 N73 15968
- SEARS, W. J.**  
Aeromedical evaluation of the phased flight concept for oxygen breathing systems p0083 N73 23065
- SEEDON, J.**  
The reduction of airframe costs with particular reference to combat aircraft p0205 N74 21615
- SEEHARS, H. D.**  
Observations with synchronously offset beams on a 77 km path at 1.8 and 4.4 cm p0118 N71 23455
- SEGERSTROM, C. A.**  
Digital versus analog communications systems: Technical and economic considerations p0133 N73 10209
- SEGNAR, H. R.**  
Automated techniques for space altimetry p0279 N73 23688
- SEIGNER, S. M.**  
The interrelation of propagation effects and design factors for fixed service communications satellite systems p0149 N74 13871
- SEIDEL, W.**  
Some recent investigations on flutter in subsonic flow caused by interference aerodynamic forces between wing and tail of a variable geometry aircraft p0009 N71 29345
- SEIDELMANN, U.**  
Discussion of steel wire reinforced aluminum alloys investigated at Battelle Institute, Frankfurt am Main p0208 N72 12501
- SEIFERT, R.**  
A method of hand display control system evaluation p0274 N72 22629
- SEKELUCK, M. A.**  
Prediction of store launch characteristics through statistical methods p0006 N71 19388
- SELLNER, H. R.**  
Differential pulse code modulation transmission of sampled aerial images p0131 N73 10139
- SELVAGGI, P.**  
Acoustic fatigue test on the VFW Fokker VAK 191 B structural components p0294 N73 29920
- SEM JACOBSEN, C. V.**  
Mental and physical environmental requirements in manned flight p0088 N74 18780
- SENSBURG, O.**  
Some recent investigations on flutter in subsonic flow caused by interference aerodynamic forces between wing and tail of a variable geometry aircraft p0009 N71 29345
- SERAFINI, T. T.**  
Marginal and structural studies of metal and polymer matrix composites p0212 N73 27491
- SEREBRENY, S. M.**  
Satellite view of the USSR as a source of radar target propagation conditions p0114 N71 21414
- SERIS, H.**  
Electric acceleration of the ionospheric plasma p0102 N72 19140  
Participatory study of spatial systems by pilots in flight p0102 N72 19148
- SERTOUR, G.**  
Evaluation of the meteorological background of flight p0214 N74 23112
- SERVANT, B.**  
Bridge effects of jet engine exhaust gases p0176 N72 20260
- SEVIGNY, L.**  
Fluid dynamic properties of subsonic flow with gas jets p0118 N72 20296
- SEYB, N. J.**  
The role of boundary layers in axial flow turbomachines and the prediction of their effects p0269 N73 19806
- SHAFFER, J. T.**  
Restraint design: Laboratory test and evaluation of operational effectiveness p0104 N72 19157
- SHANK, R. J.**  
Decisions for the 70s p0232 N73 23692
- SHANNON, R. H.**  
Operational aspects of forces on man during ejection extraction escape in the US Air Force: 1 January 1968-31 December 1970 p0102 N72 19144  
Human factors approach to aircraft accident analysis p0107 N74 18799
- SHAPIRO, J.**  
Wave height measurements with a nanosecond radar p0122 N72 16094
- SHARF, H.**  
Advanced power generation in missiles p0065 N73 19044
- SHARMA, O. P.**  
Ignition of fuels by a hot projectile p0252 N72 11663
- SHARP, J. W.**  
Potential use of composite materials for gas turbine structures p0213 N72 27495
- SHAYESON, M. W.**  
Lubricant and fuel interactions in advanced aircraft gas turbines  
[NASA CR 122842] p0254 N72 11694
- SHERIDAN, H. G.**  
Design lessons learned from the OV 10A Bronco p0028 N71 23416
- SHIELY, A. R. JR.**  
Status and trends in military traffic control systems p0232 N73 23690
- SHILLINGER, G. L. JR.**  
Responses of blind fish to gravitational changes: A "scuba" in parabolic flight p0079 N73 21101  
Human eye movements during various forms of linear acceleration and weightlessness p0109 N74 20747
- SHROUT, S. L.**  
Extension of a numerical solution for the aerodynamic characteristics of a wing to include a canard or horizontal tail  
[NASA TM X 66286] p0072 N71 19361
- SHUBROOKS, S. J. JR.**  
The use of physiological protective maneuvers in high acceleration environments p0106 N73 19156
- SICOT, J. P.**  
IMAG 2: Electronic circuit simulations p0167 N74 13927
- SIDFORD, M. J.**  
Some aspects of multipath fading in aeronautical satellite systems p0194 N72 19509
- SIEGEL, P. V.**  
The current status of drug use in aviation personnel p0080 N73 21104
- SIEMANN, H.**  
Testing of an altitude control unit for sounding rockets p0236 N74 14349
- SIEWERT, R. F.**  
Recent US Navy flying qualities research p0040 N72 32037
- SIGALLA, A.**  
The problem of installing a modern high bypass engine on a twin jet transport aircraft p0021 N74 14727
- SIGNORELLI, R. A.**  
Material and structural studies of metal and polymer matrix composites p0212 N73 27491
- SIGNORETTI, S.**  
Improvement of the properties of high strength Al-Zn-Mg alloys by thermomechanical procedures p0204 N74 23111
- SILLION, B.**  
Synthesis and properties of esters of tetraethyl 2,2,2-trifluoroethyl 1,8 p0254 N72 11696
- SILVER, B.**  
Optimization techniques in aircraft configuration design p0285 N71 20140
- SILVERTHORN, D. G.**  
The R factor in target ground acquisition modelling p0302 N73 19962
- SILVESTRE, J. C.**  
Method of measuring the material qualities of a quasi-spherical structure p0228 N73 20691
- SIMMONS, E. L.**  
Nitrogen oxides nuclear weapon testing: Concept and structural design p0212 N74 14275
- SIMON, J. C.**  
Digital flying procedures for a line image p0155 N72 11204
- SIMONPIER, P. A.**  
Redundancy of display redundancy in the management of displays p0113 N73 10189
- SIMONS, T. A.**  
Wind tunnel data elements for helicopters p0173 N73 26246
- SIMPSON, G. E. JR.**  
Four flow information analysis centers p0113 N71 19528  
Concept, system and flight test development and the flow information analysis centers p0301 N71 23507
- SIMPSON, R. W.**  
Analysis of tactical ATC system operations p0233 N73 23709

- SINCLAIR, R. D.**  
Effect of acute and chronic exposure to 31 mm Hg ambient P sub CO2 on exercise response of normal man p0070 N71 20370
- SINDLINGER, R. S.**  
Systems tests for advanced enroute navigation systems p0156 N72 21222  
Investigations on the optimization of aided inertial navigation systems p0229 N73 20697
- SINNETT, E. J.**  
Acceptance flight testing of military aircraft p0038 N72 20987
- SIRIUS, M.**  
Drag and separation p0020 N74 14722
- SIRIGNANO, W. A.**  
Ignition of fuels by a hot projectile p0252 N72 11683
- SJCEBERT, S.**  
Some development trends in the integration of electronic systems in the Swedish aircraft 37 VIGGEN p0279 N73 23889
- SKINNER, M. A.**  
Use of computers for real-time satellite checkout p0193 N72 19505
- SKLANEK, J.**  
Recog using three dimensional objects by their characteristics p0152 N72 11188
- SLATE, P. M. B.**  
Strengthening of aluminum by exposure incorporation of the helium waves p0208 N72 12502
- SLEPETS, J. M.**  
Elastic characterization of fiber reinforced composites p0207 N72 12498  
Determination of matrix and filament stress-strain properties from tests made in composites p0207 N72 12500
- SLIFF, R.**  
FAA flying standards requirements p0038 N72 32020
- SLOCUM, G. K.**  
Guidance and control computer-actuated display system techniques p0156 N72 21221
- SLOOFF, J. W.**  
A rapid estimation method for the calculation of the pressure distribution on a wing body combination at subsonic speeds p0003 N71 19164
- SMILES, K. A.**  
Analysis of the vestibuloocular conflict reflex in primates [JAGARD 71 59] p0072 N72 25040  
Performance measurement using a pilot-controlled Gz meter in a high speed aircraft p0106 N73 19151  
[JAGARD 72 3] p0106 N73 19151
- SMITH, A. M. O.**  
Anisogametes in high light and systems p0042 N73 15107  
Removal methods for predicting virus decay p0020 N74 14719
- SMITH, F. D.**  
Flight system test program of flight simulator p0229 N73 20700
- SMITH, F. H.**  
Application of dual channel laser Doppler velocimeters for wind tunnel measurements p0250 N72 25505
- SMITH, G. H.**  
Overview of an aqueous vehicle computer applications p0155 N72 21212
- SMITH, G. W. T.**  
Optimizing efficiency of drug metabolism p0082 N73 21121
- SMITH, H. G.**  
Design of helicopters for improved crash survivability p0131 N72 19141
- SMITH, J. G.**  
Hardware and computer facilities p0165 N74 13719
- SMITH, J. H.**  
The impact of advancing technology on the evolution of electronic headup display systems p0225 N72 22635
- SMITH, L.**  
A modular special PCM data conditioning system p0193 N72 19503
- SMITH, S. G.**  
Optimizing performance of the execution of multi-prioritization systems p0232 N73 20716  
An integrated system testing and evaluation in the United Kingdom p0237 N74 14352
- SMITH, T.**  
An assessment of the accuracy of transonic drag measurement in a large model wind tunnel p0022 N74 14736
- SMOLDEREN, J. J.**  
Numerical methods in fluid dynamics [JAGARD 75 48] p0181 N72 21293  
Numerical methods p0181 N72 21294  
Numerical integration of Navier-Stokes equations p0185 N74 22917
- SNIDER, D. M.**  
Efficient closed power generation for satellite communications p0194 N72 19513
- SNIVELY, G. G.**  
Evaluation and testing of electronic headgear p0164 N72 19164
- SNYDER, R. G.**  
Many susceptibility of electronic devices p0099 N72 10725
- SOBIESZCANSKI, J.**  
Automated sizing of large structures by mixed optimization methods p0297 N74 15611
- SOLOTTA, W.**  
NAK 191 B experimental program for a V-STOL Strike Recon aircraft p0054 N73 27006
- SOFFER, J. W.**  
Failure analysis of a fiber reinforced composite motor case using distortion energy and maximum strain theories of failure p0213 N73 27500
- SOLE, J.**  
Energy storage and discharge by superconductors p0064 N73 19041
- SOLEILHAVOUP, J. P.**  
Evidence on the effect of natural cooling radiation on biological stimulation p0075 N72 26350
- SOMMER, H. C.**  
Combined effects of noise and vibration on cognitive and psychomotor performance [AMIR 71 115] p0105 N73 19147
- SONGA, T.**  
Preliminary report on the research on the influence of the moment and heat treatments on stress corrosion cracking behaviour of AISI 4340 steel p0289 N73 21930
- SOOVERE, J.**  
Correlation of some fatigue failures in large fan engine ducts with simplified theory p0293 N73 29916
- SORENSEN, J. A.**  
An AIC surveillance modeling approach for specifying lane separation standards p0233 N73 23699
- SORG, M.**  
A planning strategy on the gyroscopic effects in applications [JAGARD 58 71] p0089 N71 20002
- SOULEZ-LARIVIERE, J.**  
Some thoughts on the NA-341 Gyrate speed limit p0047 N73 21018  
Rotor station flight and large aircraft engine parameters p0049 N73 21016
- SOVRANO, R.**  
Behavior of boundary layer in a corner, straight and a circular duct p0271 N73 19817
- SPAD, F. W.**  
Acoustic wave fields induced by reaction jets [JAGARD 73 173] p0184 N74 18921
- SPEER, S. M.**  
Some considerations of future low speed tunnels for Europe p0173 N74 16998
- SPENCE, A.**  
Numerical simulation of future low speed tunnels for Europe p0173 N74 16988
- SPEZIA, E.**  
Ornithopter accidents in Army aviation aircraft p0071 N72 25014
- SPIZZICCHINO, A.**  
Observations of gravity waves in the higher atmosphere by means of meteor radar detection p0137 N73 14154
- SPOONER, A. H.**  
Data storage for microcomputer applications p0193 N73 19502
- SPRING, D. J.**  
Risks of vibration at low speeds: The elimination of Reynolds number effects p0112 N72 11864
- SPROWLS, D. O.**  
Progress toward standardization of SOC test techniques by the National Association of Chemical Engineers and the American Association p0285 N72 21901  
Development of computerized test memory systems for process flow and control systems p0288 N72 21920
- STAEHEL, R. W.**  
A pusher propeller and screw propeller with a high strength steel p0281 N72 21917
- STAHL, W.**  
Force and pressure measurements on a slender delta wing at transonic speeds and variable Reynolds numbers p0112 N72 11863
- STALNAKER, R. L.**  
The biomechanical aspects of crash landing p0194 N72 19161
- STANDISH, C. J.**  
Aerodynamic input wind-tunnel configurations p0156 N72 21217
- STANGORUP, P.**  
Long range communication network analysis: Adaptation between radio channels and a digital computer p0166 N74 13916
- STANLEY, R. E.**  
The state of affairs in aerodynamics and the computer p0166 N74 13916
- STANSBERRY, C. L.**  
United States Army helicopter experience in a future war zone p0193 N72 19516
- STANTON, K. C.**  
Flavoured food preservation p0085 N74 13787
- STAPLES, K. J.**  
Motion sickness and spatial disorientation flight simulator p0166 N74 13916
- STARODORER, H.**  
Rotary steam turbine fuel injection p0112 N72 11863
- STARK, U.**  
The effect of axial velocity on the aerodynamic coefficients of a compressor cascade in incompressible flow p0269 N73 19804
- STARR, R. T.**  
High Reynolds number transonic wind tunnels: Flow down on a wing tube p0015 N72 11881
- STATES, J. D.**  
Biodynamics of sports injuries p0090 N72 19128
- STATLER, I. C.**  
Progress in rotor blade aerodynamics p0047 N73 21919
- STAVA, D. J.**  
Supersonic inlet performance and distortion during maneuvering flight p0266 N72 16713  
Inlet-airplane interference and integration p0037 N72 27018  
Assessment of the influence of inlet and airframe configuration performance on total aircraft drag p0021 N74 14726
- STEARNS, J. F.**  
User needs [NASA TM X 67142] p0301 N71 23504
- STEIN, P. K.**  
A unified approach to handling noise in measuring systems p0195 N73 10456
- STEKLY, Z. J. J.**  
Supersonic flow in steady state and pulsed applications for flight vehicles p0061 N73 19031  
Supersonic jetting generators p0064 N73 19039
- STEMBROG, A.**  
Measure of antenna radiation patterns on space-tilt p0194 N72 19512
- STEPNER, D. E.**  
An AIC surveillance modeling approach for specifying lane separation standards p0233 N73 23699
- STEPNIEWSKI, W. Z.**  
Rat aerodynamics and performance of the helicopter p0117 N73 22950
- STERLING, T. D.**  
Rat data screening: An integrated data search technique p0151 N72 11176
- STETSON, A. R.**  
The computerized stress wave analysis of the effect of various parameters on fatigue in two-dimensional alloy [NASA CR 116374] p0253 N71 17393
- STEVENSON, W. J. C.**  
Mobility of air flow in the Canadian forest related to age p0091 N71 22315  
Grassland ecology and its performance p0091 N71 22315
- STEWART, D. J.**  
The complex aerodynamic interference pattern due to transverse approximation p0004 N71 1937
- STEWART, R. H.**  
HF measurements of ocean wave for total spectra p0145 N74 13867
- STICKLAND, J. I.**  
Microwave attenuation measurements using the AIS-1 satellite p0115 N71 21419
- STILP, A.**  
The influence of wave drag on hypersonic wave characteristics p0022 N74 14133
- STOCKER, P. J.**  
An integrated system for determining the effects of gas flow conditions on fatigue and failure properties of metals p0287 N72 21916
- STOCKWELL, C. W.**  
Practical problems in aerial cinematography p0169 N74 20235  
Some of them p0169 N74 20235
- STODDART, D. L.**  
Computer simulation of a simulation p0235 N73 23715
- STODDART, J. A. P.**  
Jet effects on turbulent pressure drag of compressible systems p0265 N72 16709
- STOFFEGREN, W.**  
Excessing atmospheric disturbances induced by low altitude rocket propulsion p0139 N73 14166
- STOIBER, R.**  
Ranging transceivers for interplanetary space probes p0194 N72 19510
- STOKES, O. M.**  
A facility for high Reynolds number testing at transonic speeds [NASA TM X 674181] p0015 N72 11889
- STOKES, R. F.**  
Satellite systems and services for the automation of navigation systems p0232 N72 20716  
A multi-media system testing in a multi-media code language p0237 N74 14352
- STOLK, H. A.**  
Interference p0091 N72 23502  
Sources of sound in a reacting jet p0193 N73 23505
- STOLLE, E.**  
Design of geometry and interconnectivity for a respiratory space probe p0093 N72 19508
- STOLLERY, J. L.**  
The test bench for a multi-media system and its components p0193 N73 23505
- STOLTZ, C.**  
Study of low frequency forcing system by hydrodynamic of turbulence p0112 N72 11863

- STONE, M. H.**  
A new test for the glass to resin bond life in GRP  
Comparison of typical systems exposed to water  
p0208 N72 12505
- STOOP, D. R.**  
Elevated blood pressure in aircrew  
p0085 N74 13787
- STOTTMANN, P.**  
Temperature measurements with thermocouples including errors caused by catalytic effects  
p0257 N71 17379
- STRAETER, T. A.**  
An analytic study of near terminal area optimal sequencing and flow control techniques  
p0233 N73 23701
- STRATTON, A. W.**  
Comparison of 15 GHz propagation data from the ATS-5 satellite with ground based radio and meteorological data  
p0115 N71 21418  
Statistics on earth satellite attenuation at two Texas locations  
p0142 N73 26141
- STRANE, V.**  
Real time programs for aerospace vehicles  
p0155 N72 21215
- STRAWSON, H.**  
Fuels for supersonic and hypersonic aircraft  
p0251 N72 11871  
Electrostatic charging in the handling of aviation fuels  
p0253 N72 11886
- STRICKLAND, J. I.**  
Comparison of direct and indirect measurements of precipitation attenuation at 15.7 GHz  
p0143 N73 26142
- STRINGER, J.**  
High temperature corrosion of aerospace alloys  
[AGARD CP 120]  
p0201 N73 23597  
Are there new approaches to alloying which may produce oxidation resistant refractory metal alloys?  
p0203 N73 22715
- STULLER, J. A.**  
Differential pulse code modulation transmission of compressed aerial imagery  
p0131 N73 0190
- STUMPF, O.**  
Advanced power generation in missiles  
p0065 N72 19044
- STUREK, W. B.**  
The supersonic turbulent boundary layer in an adverse pressure gradient: Experiment and data analysis  
p0129 N72 20300
- STURGEON, J. R.**  
Influence of pilot and aircraft characteristics on structural loads in operational flight  
[AGARD R 608]  
p0057 N73 27895  
Influence of pilot and aircraft characteristics on structural loads in operational flight  
[AGARD R 608]  
p0058 N74 17728
- SUCIU, S. N.**  
High temperature turbine design considerations  
p0258 N71 17386
- SULLIVAN, J. F.**  
Propagation of 15.6, 31.2 GHz and 45, 90 GHz coherent signal pairs  
p0141 N73 26131
- SUMERLIN, W. T.**  
Techniques of system reliability estimation including failure effect analysis failure consequences  
p0189 N71 36777  
Effectiveness of reliability program elements  
p0189 N71 36779  
System operational considerations and their relationship to the test process  
p0190 N71 36785
- SUMMERS, D. E.**  
Realistic considerations of target acquisition in times of communications  
p0304 N73 19971
- SURBER, L. E.**  
Supersonic inlet performance and distortion during maneuvering flight  
p0266 N72 16710  
Inlet-airplane interference and integration  
p0037 N72 27018  
Assessment of the influence of inlet and albedo on the performance of total aircraft drag  
p0021 N74 14726
- SURROQUE, J.**  
Boundary layer effects in turbomachinery  
[AGARD AG 164]  
p0268 N73 19794
- SUTCLIFFE, D. L.**  
Separation criteria for densely packed stores in bomb bays  
p0005 N71 19383
- SWAN, W. C.**  
Configuration aspects of propulsion installation on supersonic transports  
p0004 N71 19373  
The problem of installing a modern turbojet engine on a twin jet transport aircraft  
p0021 N74 14727
- SWANSON, R. W.**  
High altitude signal transmission characteristics  
p0129 N72 21444
- SWECKER, G. E.**  
Greater safety, maneuverability and stability through improved helicopter flight testing  
p0477 N72 21013
- SWEETING, D.**  
Some design aspects of the stability augmentation system for the W-130 light attack helicopter  
p0073 N72 11730
- SWENSKI, D. F.**  
Advanced airborne auxiliary power system  
p0062 N73 19045
- SYKES, O. M.**  
Sting interference effects on the behavior of transonic speeds  
p0022 N74 14717
- SYMEONIDES, P. P.**  
Some observations on the use of the cross flow shock wave ejector for jet propulsion  
p0102 N72 19149
- SYRE, R.**  
Characterization, selection and use of titanium base alloys  
p0210 N71 27045
- SZALKOWSKI, A. S.**  
The Automated Technical Control (ATEC) system  
p0133 N73 10207
- T**
- TAIG, I. C.**  
General considerations in the applications of advanced composites  
p0210 N72 29595  
Airframe applications of advanced composites  
p0210 N72 29596  
Design concepts for the use of composites in airframes  
p0210 N73 27479  
Optimization of aircraft structures with multiple stiffness requirements  
p0297 N74 15612
- TAILLON, N. V.**  
Techniques for the evaluation of air breathing propulsion systems in full scale flight  
[NASA TM X 68305]  
p0035 N72 20983
- TAISSEIRE, K.**  
Analysis of the effects of external stores fastened under an air wing on the longitudinal stability of that aircraft  
p0005 N71 19382  
Analysis of combat aircraft applications for lift augmentation devices  
p0026 N71 20059
- TAKEMORI, S.**  
Visual vestibular interaction: The role of the labyrinth in the production of optokinetic nystagmus and optokinetic after nystagmus  
p0109 N74 20743
- TALL, M. M.**  
Correlation between estimation tests and system operation data  
p0189 N71 36778  
Cost effectiveness of built-in test provisions  
p0189 N71 36780  
Relationships between program test and user support costs  
p0190 N71 36784
- TALLAN, N. M.**  
Prospects for oxidation resistant refractory compounds  
p0203 N73 23616
- TAMURA, J. H.**  
P-4: a low cost IMU resulting from optimum system design  
p0278 N73 20990
- TANNER, L. H.**  
Effects of coherence on flow visualization methods  
p0199 N72 25497
- TANNER, M.**  
Experimental investigation of the drag of wings with a blunt trailing edge  
p0012 N72 11862  
New investigations for reducing the base drag of wings with a blunt trailing edge  
p0020 N74 14723
- TARDIF, L.**  
Fluid dynamic properties of turbulent wakes of hypersonic spheres  
p0178 N72 20296
- TARRIERE, C.**  
Comparison of the effectiveness of two passive restraint systems  
p0099 N72 19126
- TAURITZ, J. L.**  
DAP: Distribution Analysis Program: A program for the analysis and design of microwave circuits  
p0166 N74 14971
- TAYLOR, C. R.**  
Some factors relevant to the simulation of full scale flows in model tests and to the specification of new high Reynolds number test facilities  
p0015 N72 11883  
The need for high Reynolds number testing  
p0183 N73 26282
- TAYLOR, D.**  
Ejector design for a variety of applications  
p0183 N73 17252
- TAYLOR, D. S.**  
Optimum sparseborne computer system design by simulation  
p0279 N73 23891
- TAYLOR, G. N.**  
Non-singular atmospheric chatter in the VHF and UHF bands  
p0128 N72 21134
- TAYLOR, J.**  
Operational considerations and applications of the T-1474 landing aid to T-1474  
p0012 N72 11925  
Slotted rotor aircraft using circulation controlled rotors  
p0048 N73 21024
- TAYLOR, J. H.**  
Air to ground visibility of lights at low background levels  
p0303 N73 19967
- TAYLOR, M.**  
An optimum military helicopter navigation system  
p0031 N72 11921
- TAYLOR, M. J.**  
Lessons from operations and trials of twin rotor propeller driven helicopters  
p0028 N71 23477
- TAYLOR, R. F.**  
Activation of a general method for flutter optimization  
p0297 N74 15619
- TEAGUE, C.**  
HF measurements of ocean wave electric field spectra  
p0148 N74 13867
- TEMAN, R.**  
Application of Navier-Stokes equations  
p0181 N72 27276
- TEMIN, R.**  
The approximation of Navier-Stokes equations for viscous flow problems  
p0131 N72 27277
- TEMPLEMAN, A. S.**  
Structural design applications of geometric programming  
p0296 N74 15801
- TETELMAN, A. S.**  
Mechanical behavior of S-O2 epoxy composite  
p0207 N72 12499
- THAYER, G. D.**  
Worldwide characteristics of refractive index and climatological effects  
p0114 N71 21412  
Reflections from elevated layers in transhorizon radio propagation  
p0116 N71 21424
- THIELEMANN, W. F.**  
Experience with composites as obtained from grids  
p0211 N73 27486
- THOMAS, D. J.**  
Human dynamic response to minus Gx impact acceleration  
p0100 N72 19131  
Theoretical mechanics for expressing impact acceleration response of human beings  
p0100 N72 19132  
Specialized anthropometry requirements for protective equipment evaluation  
p0084 N73 23086
- THOMAS, F.**  
A method for calculating the transonic buffet boundary including the influence of Reynolds number  
p0011 N72 11857
- THOMAS, H. H. S. M.**  
The role of theoretical studies of light dynamic simulation to flight testing  
p0045 N73 17011
- THOMAS, J. M. L.**  
Ground handling techniques and systems  
p0195 N73 10453
- THOMAS, J. O.**  
The polar exospheric plasma  
p0126 N72 21124
- THOMAS, R. D.**  
Design optimization of SRAM inertial navigation and guidance  
p0230 N73 20705
- THOME, G. O.**  
Phase coherent HF radar observations of barium release in the Arctic ionosphere  
p0128 N72 21136
- THOME, R. J.**  
Superconductivity in steady state and pulsed applications for flight vehicles  
p0083 N73 19035
- THOMPSON, A. J.**  
Returning aircraft with abnormal engine tests and normal coronary angiograms to flying status  
p0085 N74 13788
- THOMPSON, M. O.**  
Lifting body flight test techniques  
[NASA TM X 68306]  
p0035 N72 20986
- THOMPSON, R. J.**  
Failure analysis of a fiber reinforced composite motor case using distortion energy and maximum strain in the area of failure  
p0213 N73 27500
- THOMPSON, R. L.**  
Optimization of a deaeration unit for ion exchange using a synchronized time division multiplex communication system  
p0234 N73 23711
- THOMPSON, A. G. R.**  
Acoustic fatigue design data: part 1  
[AGARD AG 162 P1-1]  
p0290 N72 29893  
Acoustic fatigue design data: part 2  
[AGARD AG 162 P1-2]  
p0291 N73 14848  
Design data for acoustic fatigue  
p0293 N73 29914  
Acoustic fatigue design data: part 3  
[AGARD AG 162 P1-3]  
p0298 N74 19550
- THORNBY, J. I.**  
Normal tests for the sequential bifurcation algorithm  
p0109 N74 20743
- THORNE, R. G.**  
Post workload: A conceptual model  
p0045 N73 17010
- THUMLER, R.**  
Human eye movements during various forms of acceleration and weightlessness  
p0109 N74 20747
- THURMAN, W. E.**  
A review of V-STOL aircraft accidents in the US  
p0029 N71 23426
- TIANO, A.**  
Determination of an optimal trajectory in the presence of wind  
p0279 N73 23886
- TIGERT, J.**  
New basis of classification and selection of aluminum alloys  
p0206 N71 27044
- TJONNELAND, H.**  
Unsteady aerodynamics for wings with curved surfaces  
p0063 N71 29346  
On the prediction of aerodynamic loads on rotating wings in transonic flow  
[AGARD R 612]  
p0023 N74 18657
- TIMME, A.**  
Effect of turbulence and air flow on the aerodynamic environment of the aircraft  
p0181 N73 26284
- TINCANI, B.**  
Assessment of air traffic control in Italy: the Rome Area  
p0127 N73 21694
- TIXADOR, R.**  
Experiments on the effect of natural convection on the aerodynamic environment of a structure  
p0075 N72 26050
- TJONNELAND, U.**  
Effects of area ratio on the aerodynamic environment of a structure  
p0127 N73 21694
- TJONNELAND, E.**  
The design of a transport aircraft for a high speed transport system  
p0265 N72 16703

## VANDERHEYDE R C W

- B. 2f.**

## WILLIAMS, D. P.

- VESSELING, P.**  
A calculation method for three dimensions of a compressible turbulent boundary layer. p0117 N72 20285
- WESTBROOK, C. B.**  
US military V-STOL handling quality requirements. p0038 N72 30223
- Mission effects on stability and maneuverability. p0044 N73 16995
- WESTIN, H.**  
Determination of heat transfer coefficient by moving airfoil microprobes. p0735 N73 14138
- WESTLEY, R.**  
Surface pressure fluctuations from jet impingement on an inclined flat plate. p0292 N73 23909
- WHEATLAND, W. L.**  
Air (COB) base alloys: extremely easy metal resistant to hot corrosion than alloys based on nickel. p0203 N73 23612
- WHEELER, R. H.**  
Analysis of the vestibulo-ocular counterroll reflex in primates. [AMRL TR 71-59] p0072 N72 25049
- WHICHER, P. G.**  
Technical evaluation report of 231 Aerospace Panel Technical Meeting on Aerospace Telecommunications Systems, 15-18 May 1972. p0131 N73 01888
- WHITE, C. S.**  
The thermodynamics of an blast. p1020 N72 19134
- WHITE, E. A.**  
Lithographic lensless x-ray effects in the engine Part 2: Thermodynamic problems and the possible solutions. p0026 N73 20662
- WHITE, F. M.**  
A sample analysis of two dimensional turbulent shock-turbulence with a binary wall and freestream conditions. p0176 N72 20279
- WHITE, K. O.**  
Edmon river propagation in a GOF atmosphere with near-100% humidity. p0124 N72 16109
- WHITE, R. A.**  
A study of flow separation in the base region and its effects on drag powered flight. p0023 N74 14724
- WHITESIDE, T. C. D.**  
Mixtures for propellant compatibility. p0057 N74 12713
- [JAGUAR AR 56]  
WIGHTFIELD, J. D.

[illegible]



- WILLIAMS, J.**  
Aircraft performance: Prediction methods and optimization  
[AGARD LS 56] p0052 N73 24042  
Aircraft performance prediction methods for transport and combat aircraft p0053 N73 24044  
Acoustic considerations for noise experiments at model scale in subsonic wind tunnels p0173 N73 26247
- WILLIAMS, K. J.**  
Can fuel ash corrosion by vanadium be combated by alloying or coating without the use of fuel additives? p0203 N73 23613
- WILLIAMS, P. R. G.**  
The complex aerodynamic interference pattern due to rear fuselage mounted powerplants p0204 N71 19375
- WILLIAMS, T. M.**  
Recent developments in circulation control rotor technology p0051 N73 21050
- WILLIAMS, T.**  
Optimum spaceborne computer system design by simulation p0275 N73 23891
- WILLIAMSON, R. G.**  
Wind tunnel testing of V. STOL engine models: Some observed flow interaction and tunnel effects p0264 N72 15693
- WILLMARTH, W. W.**  
Structure of the Reynolds stress near the wall p0175 N72 20275
- WILSON, C. R.**  
Normal infrasonic wave generation mechanism p0135 N73 14137
- WILSON, G. J.**  
Evaluation, development, and advantages of the helicopter: tandem dual cargo hook system p0048 N73 21022
- WILSON, G. P.**  
Flight development of the stalling characteristics of a military trainer aircraft p0042 N73 15932
- WILSON, J. W.**  
Human factors in low weather operation of transport aircraft p0281 N72 23901
- WILSON, R. E.**  
Ablation  
[AGARD AG 151] p0299 N72 24959  
Aerodynamic interference induced by reaction control [AGARD OGRAPH 173] p0184 N74 18223
- WIMPRESS, J. K.**  
Predicting the low speed stall characteristics of the Boeing 747 p0043 N73 15010
- WINKELMANN, A. E.**  
Aerodynamic interaction phenomena produced by a fin protruding radially immersed in a turbulent boundary layer at Mach 5 p0003 N71 19365
- WINNY, H. F.**  
Use of ion positions in helicopters: Advantages and disadvantages p0211 N73 27483
- WINTER, H.**  
The modeling error sensitivity of digital filters for the alignment of aerostat stations p0230 N72 20708
- WINTER, K. G.**  
Measurements of the drag of some characteristic aircraft excrescences immersed in turbulent boundary layers p0019 N74 14714
- WINTERBOTTOM, S. K.**  
Structural design applications of geometric programming p0296 N74 15601
- WINTERFELD, G.**  
Investigation of free expansion power law by means of a new in-situ procedure p0253 N72 16691
- WINTROUB, H. J.**  
Space communications systems compatibility at 94 GHz p0143 N73 16143
- WINZER, G.**  
Holographic pattern recognition using a matched filter correlator p0153 N72 13114
- WIPPLER, C.**  
Characterization selection and use of polymeric materials p0205 N71 27242
- WIRZ, H. J.**  
Numerical integration of Navier-Stokes equations p0185 N74 22917
- WOLBARST, M. L.**  
Laser safety and how to promote it p0276 N72 26056  
Theoretical aspects of color vision p0277 N73 19066
- WOLF, N. D.**  
Design and static fatigue characteristics of composite material components p0293 N73 29918
- WOLFE, J. W.**  
Aeronautical research and flight applications of aerodynamic techniques in hypersonic flow p0110 N74 20759
- WOLOWICZ, C. H.**  
Flight test experience in aircraft parameter identification p0046 N73 17012
- WOOD, E. H.**  
Effect of positive G<sub>y</sub> on integration of blood oxygen saturation and pleural pressure relationships in dogs breathing first air then liquid fluorocarbon while body water remains on respirator [NASA CR 117199] p0068 N71 20358
- WOOD, M. A.**  
The use of fracture mechanics principles in the design and analysis of damage tolerant aircraft structures p0234 N73 29928  
A summary of crack growth prediction techniques p0295 N73 29932
- WOODCOCK, D. L.**  
A supersonic hot calculation method for the calculation of unsteady airfoils of tandem surfaces p0008 N71 29337  
A comparison of methods used in lifting surface theory [AGARD R 583 71] p0010 N71 35198
- WOODRUFF, K. R.**  
Rate of closure as a performance as a performance monitoring parameter p0226 N72 22643
- WOODSON, H. H.**  
Superconducting generators p0064 N73 19039
- WOODWARD, J. D.**  
Separation criteria for densely packed stores in bomb bays p0005 N71 19383
- WOOLCOCK, S. C.**  
Target characteristics p0144 N74 11960  
Use of radio modelling data p0145 N74 11965
- WOOLLEY, J. H.**  
Surface pressure fluctuations from jet impingement on an inclined flat plate p0292 N73 29909
- WORTMAN, A.**  
Parametric studies of separating turbulent boundary layer flows p0041 N73 15003
- WORTMANN, F. Y.**  
Design of airfoils with high lift at low and medium subsonic Mach numbers p0042 N73 15094
- WOTTON, J.**  
Piezometric response characteristics p0056 N73 19056
- WRIGHT, C. M.**  
Use of hypothesis by review: Operational considerations and experimental studies p0080 N73 21116
- WRIGHT, H. T.**  
The influence of cost and technical risk on the design of the aircraft system for the space shuttle p0278 N73 23884
- WRIGHT, I. G.**  
Armed: NATO national reports on high temperature combustion of aerospace systems: A topical listing of the research programs p0203 N73 23618
- WRIGHT, R. C.**  
Library and information services at the Royal Aircraft Establishment: Some problems and their present solutions p0158 N73 24204
- WU, C.**  
A computer program for analyzing waveguide structures p0166 N74 13919
- WU, J. M.**  
Subsonic flow at small angles of attack: The effects of Reynolds number effects p0012 N72 11864
- WUENNEBERG, M.**  
V. STOL handling qualities criteria compared with flight test results of the V. STOL transport aircraft OC 316 and the V. STOL transport aircraft OC 316 p0039 N72 32024
- WUERKER, R. F.**  
Pulsed laser holography  
[NASA CR 126762] p0199 N72 25501  
Pulsed laser holography p0200 N72 25502
- WUEST, W.**  
Drag in hyper and choked flow p0021 N74 14730
- WULF, R.**  
Jet stimulation and jet interference effects on tailplane p0034 N71 19374  
Use of model engines in V. STOL p0173 N73 26245
- WULFSBERG, K. N.**  
Rain attenuation at millimeter wavelengths p0114 N71 21415
- WYETH, H. W. G.**  
Fire and explosion protection of jet engine engine p0253 N72 11690
- WYKES, J. H.**  
Flying stability: interaction with elastic frames p0039 N72 32031
- WYNN-PARRY, C. B.**  
Improved methods of clinical electrodiagnosis in diagnosis of lower motor neuron lesions p0074 N72 25058
- Y**
- YAGGY, P. F.**  
Progress in turbomachinery aerodynamics p0047 N73 21019  
The role of aerodynamics and dynamics in military and civilian applications of rotary wing aircraft p0017 N73 22949  
Dynamic stall  
[NASA CR 136473] p0018 N74 13709  
Magnus characteristics of rotating bodies  
[AGARD AG 171] p0018 N74 13710
- YANOWITZ, F. G.**  
Performing an experiment with atmospheric test cells and wind tunnel air and gas flows in a static cell p0085 N74 13788
- YANTA, W. J.**  
An experimental study of the compressible turbulent boundary layer with an adverse pressure gradient p0179 N72 20239
- YAPLEE, B. S.**  
Wave height measurements with a laser interferometer p0122 N72 16794
- YEH, K. C.**  
O. waves generated by stationary and traveling sources in an inhomogeneous medium p0135 N73 14119
- YFF, J.**  
Total aerodynamic analysis for Fokker F 28 p0009 N71 29344  
Rational calculation of design gust loads in relation to present and proposed airworthiness requirements p0059 N74 17740
- YORK, E. J.**  
A supersonic box iteration method for the calculation of unsteady airfoils of tandem surfaces p0008 N71 29337
- YOSHIHARA, H.**  
The transonic performance of two-dimensional jet flap airfoils at high Reynolds numbers p0112 N72 11861  
Some recent developments in planar inviscid transonic flow theory  
[AGARD AG 156] p0016 N72 22001  
Transonic drag due to lift of planar jet flapped airfoils p0202 N74 14720  
A survey of computational methods for 2D and 3D transonic flows with shocks p0185 N74 22920
- YOUNG, A. D.**  
An experimental investigation of the turbulent boundary layer along a streamwise corner p0180 N72 20332
- YOUNG, B.**  
Aircraft response to turbulence crew comfort assessments using power spectral density methods p0059 N74 17729
- YOUNG, L. R.**  
Integrated display principles and some applications to V. STOL aircraft  
[NASA CR 126153] p0224 N72 22600  
Automated hysteresis analysis p0110 N74 20757
- YOUNG, W. H. JR.**  
A summary of current research in rotor unsteady aerodynamics with emphasis on work at Langley Research Center p0050 N73 21041
- Z**
- ZALOVICK, J. A.**  
Vector wave research p0058 N74 17733
- ZANEVALD, J. R. V.**  
Variation of optical sea parameters with depth p0241 N73 33626
- ZAPP, R.**  
Effect of vegetation upon antenna pattern with scatter propagation model p0117 N71 23161
- ZAVODY, A. M.**  
The influence of radiation line of sight propagation at 110 GHz in SE England p0142 N73 26135
- ZEMLIN, G. F.**  
Computers for terrain C. D. and Omega navigation and guidance systems p0157 N72 21225
- ZERKLE, H. G.**  
Flight recording in NATO countries: second edition  
[AGARD AG 39] p0195 N72 32457
- ZIEBARTH, H. A.**  
Homogeneous deformation of stiffened shells for radio telescope structures p0298 N74 15616
- ZIEBLAND, H.**  
Heat transfer in turbo engines  
[AGARD AG 148 71] p0293 N72 12950
- ZIMMER, H.**  
The rotor in axial flow p0050 N73 21039
- ZIMMERMAN, D. R.**  
The effect of free stream turbulence level on turbulent boundary layer behaviour p0268 N73 19799
- ZINNEMANN, G.**  
Integration of conference management p0036 N74 23495
- ZIPFEL, J.**  
The automatic analysis of the EEG at rest during and after exercise with two different computer systems p0073 N72 25052
- ZOCHER, H. J.**  
Full scale fatigue requirements for rotor fatigue life prediction p0061 N74 19557
- ZONARS, D.**  
The transonic performance of two-dimensional jet flap airfoils at high Reynolds numbers p0012 N72 11861  
Dynamic characteristics of engine nozzles p0037 N72 22022  
The vortex drag due to lift of planar jet flapped airfoils p0202 N74 14720
- ZUERNDORF, H.**  
Pulse Doppler radar: a tutorial: Representative parameters and associated beam control considerations p0227 N72 27691
- ZVARA, J.**  
Analysis of terminal ATC system operation p0233 N73 23700
- ZWAAN, R. J.**  
Total aerodynamic analysis for Fokker F 28 p0009 N71 29344  
The transonic performance of two-dimensional jet flap airfoils at high Reynolds numbers p0012 N72 11861  
On the properties of aerodynamic loads on rotor wings: transonic flow  
[AGARD AG 171] p0018 N74 13710
- ZWAANEVELD, J.**  
Comparison of experimental results for calculating the lift and thrust pressure measurements in the rear wake at subsonic speeds p0202 N74 14721



## CORPORATE SOURCE INDEX

- C.2

## AIR FORCE SYSTEMS COMMAND, WRIGHT PATTERSON AFB, OHIO

AEROSPACE CORP. EL SEGUNDO CALIF

© 1997 by The McGraw-Hill Companies, Inc.

[illegible][illegible]

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26





## CORPORATE SOURCE INDEX

## CIVIL AEROMEDICAL INST OKLAHOMA CITY OKLA

[illegible]

CLEMENS HOSPITAL MÜNSTER (WEST GERMANY)  
Phys. Ed. for ex. 3. 1. 1979 (1909) 1. 1. 2. 30

CO-MISSAIAI A L'ENERGIE ATOMIQUE SACLAY  
(FRANCE)  
Energy Storage in the Range 10<sup>3</sup> to 10<sup>4</sup> J  
1966-1971

COMMUNICATIONS RESEARCH CENTRE OTTAWA  
(ONTARIO)  
Short-Range Microwave Interference in the Atmosphere  
and its Effect on the Propagation of Radio Waves  
1961-1971

Weather radar image, 1000 UTC 12/11/18 10115.4/121118

[illegible]

Copyright © 1997 by John Wiley & Sons, Inc.  
Published by John Wiley & Sons, Inc. 605 Third Avenue, New York, NY 10158-0001  
Printed in the United States of America  
10 9 8 7 6 5 4 3 2 1

COMPAGNIA INDUSTRIALE AEROSPAZIALE S.p.A.

ROME ITALY  
Des. 518,900  
COMPAGNIE GENERALE DE TELEGRAPHIE SANS

FIL PARIS (FRANCE)  
 Digital Imaging and Graphics  
 1975-1976

COMPUTER AIDED DESIGN CENTRE CAMBRIDGE  
ENGLAND:

COMPUTER SCIENCES CORP FALLS CHURCH VA  
 Providing services for a large number of

COMPUTING DEVICES OF CANADA LTD. OTTAWA  
(ONTARIO)

CONNECTICUT UNIV STORRS

CONSIGLIO NAZIONALE DELLE RICERCHE GENOVA  
(ITALY)

CONSIGLIO NAZIONALE DELLA RICERCA PISA  
(ITALY)

CONS. GLIO NAZIONALE DELLE RICERCHE ROME  
(ITALY)

CORNELL AERONAUTICAL LAB INC BUFFALO N

As a result of the above, the following theorem can be proved.

[illegible]

CORNELL UNIV ITHACA NY  
GRANFIELD INST OF TECHNOLOGY (ENGLAND)

[illegible]

where  $\mathbf{p} = (p_1, \dots, p_n)$  and  $\mathbf{q} = (q_1, \dots, q_n)$  are the vectors of the probabilities of the events  $\omega_1, \dots, \omega_n$  and  $\omega'_1, \dots, \omega'_n$  respectively. Then the entropy of the system  $S$  is defined as

$$H(\mathbf{p}) = -\sum_{i=1}^n p_i \log p_i, \quad H(\mathbf{q}) = -\sum_{i=1}^n q_i \log q_i, \quad H(\mathbf{p}, \mathbf{q}) = -\sum_{i=1}^n (p_i + q_i) \log (p_i + q_i).$$
[illegible]

CURTISS WRIGHT CORP WOOD BRIDGE NJ

## D

## DE HAVILLAND AIRCRAFT CO. LTD. DOWNSVIEW (ONTARIO)

Some aspects of computer for the engine running concept  
[NASA CR 125540] p0264 N72 18698

The Buffalo Speyjet STO research aircraft  
p0255 N72 22310

Data on computerized analysis of the earth's atmosphere shear layer for STO design data  
p0259 N74 17737

## DEFENCE AND CIVIL INST. OF ENVIRONMENTAL MEDICINE DOWNSVIEW (ONTARIO)

Measurement of susceptibility to motion sickness  
p0278 N72 21093

The human computer interface problem in the cockpit  
p0235 N72 22716

The human factor in cockpit accident and test patterns  
p0207 N74 18830

## DEFENCE RESEARCH ESTABLISHMENT VALCARTIER (QUEBEC)

Fluid dynamic properties of flow over wings of hypersonic  
p0278 N72 20296

## DEFENCE RESEARCH INFORMATION CENTRE ORPINGTON (ENGLAND)

Taken to laboratory and field tests. A review for  
p0259 N72 24210

## DEFENCE SCIENTIFIC INFORMATION SERVICE OTTAWA (ONTARIO)

Information on the development of  
p0203 N72 22343

Development of a new type of aircraft  
p0259 N72 24209

A new type of aircraft for the future  
p0259 N74 18827

## DEFENSE DEPT. WASHINGTON D.C.

Defense Dept. Air Force Dept. Air Force Dept.  
p0230 N72 21316

## DEFENSE DOCUMENTATION CENTER ALEXANDRIA VA

A review of the development of the  
p0230 N74 18935

## DELAWARE UNIV. NEWARK

A review of the development of the  
p0230 N74 18935

## DUFFY UNIV. OF TECHNOLOGY (NETHERLANDS)

A review of the development of the  
p0230 N74 18935

## DEMOCRITUS NUCLEAR RESEARCH CENTER ATHENS (GREECE)

A review of the development of the  
p0230 N74 18935

## DEPARTMENT OF ENERGY MINES AND RESOURCES OTTAWA (ONTARIO)

A review of the development of the  
p0230 N74 18935

## DEPARTMENT OF TRANSPORTATION CAMBRIDGE MASS

A review of the development of the  
p0230 N74 18935

## DEPARTMENT OF TRANSPORTATION WASHINGTON D.C.

A review of the development of the  
p0230 N74 18935

## DEPUTY CHIEF OF NAVAL OPERATIONS (DEVELOPMENT) WASHINGTON D.C.

A review of the development of the  
p0230 N74 18935

## DEPUTY INSPECTOR GENERAL FOR INSPECTION AND SAFETY (AIR FORCE) NORTON AFB CALIF.

A review of the development of the  
p0230 N74 18935

## DETROIT DIESEL ALLISON INDIANAPOLIS IND.

A review of the development of the  
p0230 N74 18935

## DEUTSCHE BUNDESPOST DARMSTADT (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DEUTSCHE FORSCHUNGS UND VERSUCHSANSTALT FUER LUFT UND RAUMFAHRT BAD GODENBERG (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DEUTSCHE FORSCHUNGS UND VERSUCHSANSTALT FUER LUFT UND RAUMFAHRT BERLIN (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DEUTSCHE FORSCHUNGS UND VERSUCHSANSTALT FUER LUFT UND RAUMFAHRT BRUNSWICK (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DEUTSCHE FORSCHUNGS UND VERSUCHSANSTALT FUER LUFT UND RAUMFAHRT STUTTGART (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DEUTSCHE FORSCHUNGS UND VERSUCHSANSTALT FUER LUFT UND RAUMFAHRT STUTTGART (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

The proposed jet of a STO aircraft  
p0265 N72 16730

A method of for calculating the transverse buffet boundary  
p0211 N72 11857

## DEUTSCHE LUFTHANSA AKTIENGESellschaft FRANKFURT AM MAIN (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DEVELOPMENT AND RESOURCES TRANSPORTATION CO. SILVER SPRING MD.

A review of the development of the  
p0230 N74 18935

## DIRECTION TECHNIQUE AVIONS PARIS (FRANCE)

A review of the development of the  
p0230 N74 18935

## DORNIER SYSTEM G.M.B.H. FRIEDRICHSHAFEN (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DORNIER WERKE G.M.B.H. FRIEDRICHSHAFEN (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. LONG BEACH CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## DOUGLAS AIRCRAFT CO. INC. SANTA MONICA CALIF.

A review of the development of the  
p0230 N74 18935

## E

## ECOLE D'APPLICATION DES HAUTS POLYMERES STRASBOURG (FRANCE)

A review of the development of the  
p0230 N74 18935

## ECOLE DES MINES PARIS (FRANCE)

A review of the development of the  
p0230 N74 18935

## ECOLE NATIONALE SUPERIEURE DE L'AERONAUTIQUE TOULOUSE (FRANCE)

A review of the development of the  
p0230 N74 18935

## ECOLE NORMALE SUPERIEURE PARIS (FRANCE)

A review of the development of the  
p0230 N74 18935

## ECOLE ROYALE MILITAIRE BRUSSELS (BELGIUM)

A review of the development of the  
p0230 N74 18935

## EDINBURGH UNIV. (SCOTLAND)

A review of the development of the  
p0230 N74 18935

## ELECTRONIC SYSTEMS DIV. BEDFORD MASS.

A review of the development of the  
p0230 N74 18935

## ELECTRONIC SYSTEMS DIV. L. G. HANSCOM FIELD MASS.

A review of the development of the  
p0230 N74 18935

## ELECTRONIQUE MARCEL DASSAULT ST. CLOUD (FRANCE)

A review of the development of the  
p0230 N74 18935

## ELEKTRONIKCENTRALEN HOERSHOLM (DENMARK)

A review of the development of the  
p0230 N74 18935

## ELEKTRONIK SYSTEM G.M.B.H. MUNICH (WEST GERMANY)

A review of the development of the  
p0230 N74 18935

## ELLIOTT FLIGHT AUTOMATION LTD. ROCHESTER (ENGLAND)

A review of the development of the  
p0230 N74 18935

## ELLIOTT FLIGHT AUTOMATION LTD. ROCHESTER (ENGLAND)

A review of the development of the  
p0230 N74 18935



Some engineering and operational factors of multisensor display  
**EMI ELECTRONICS LTD., WELLS (ENGLAND)**  
 Introduction lecture: Target scattering characteristics of importance to radars  
 Modelling methods of determining radar echo characteristics  
 Target characteristics  
 Use of radar modelling data  
 State of the art and future prospects

**ENGINEERING SCIENCES DATA UNIT, LONDON (ENGLAND)**  
 Design data for acoustic fatigue  
 Appendix: A data item service for aircraft drag estimation

**ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION, BOULDER COLO**  
 Worldwide characteristics of refractive indices and climatological effects  
 Reflections from elevated layers in transhorizon radio propagation

**ERLANGEN-NÜRNBERG UNIV. (WEST GERMANY)**  
 Fundamental subjects of gerontology and particularities of genetics

**ERNO RAUMFAHRTSTECHNIK G.M.B.H. BREMEN (WEST GERMANY)**  
 Development results of the ESRO TO satellite pneumatic system  
 Advanced power generation in missiles

**ESSO DEVELOPMENT CO., LTD., ABINGDON (ENGLAND)**  
 Aviation fuel lubricity  
 Stability of synthetic aviation gas turbine lubricants at high temperatures

**EUROCONTROL AGENCY, BRUSSELS (BELGIUM)**  
 Air traffic control in the Eurocontrol area

**EUROPEAN ATOMIC ENERGY COMMUNITY, ISPRA (ITALY)**  
 Heat exchange and heat exchangers with liquid metals

**EUROPEAN ATOMIC ENERGY COMMUNITY, LUXEMBOURG**  
 Abstracts on microfilm for on-line retrieval

**EUROPEAN SPACE RESEARCH ORGANIZATION, PARIS (FRANCE)**  
 Aerospace information services: Progress with the ESRO ELDO computerized information network

## F

**FARRAND OPTICAL CO., INC., VALHALLA, N.Y.**  
 A multipurpose wide field-of-view dimensional heat-wire display for aircraft

**FEDERAL AVIATION ADMINISTRATION, WASHINGTON, D.C.**  
 FAA flying qualities requirements  
 The current status of drug use in civil aviation personnel

Status and trends in civil air traffic control systems  
 Wake Vortex Avoidance System program (WVAS)

**FEDERAL GERMAN POST OFFICE, DARMSTADT (WEST GERMANY)**  
 Methods of distinguishing scatter and partial reflection at tropospheric transhorizon paths  
 Observations on a 12 GHz scatter line over a 210 km path

Some observations of scattering from rain on a 12 GHz trans horizon link  
**FENDLER (C) HAMBURG (WEST GERMANY)**

Remote sensing and atmospheric layers  
 The phase of a plane electromagnetic wave transmitting wide spread atmospheric inhomogeneity

**FERRANTI PACKARD ELECTRIC LTD., TORONTO (ONTARIO)**  
 Lightweight superconduction magnet for airborne MHD generators

**FERRANTI LTD., BRACKNELL (ENGLAND)**  
 Problems involved in ATF automation

**FERRANTI LTD., EDINBURGH (SCOTLAND)**  
 A navigation computer and display unit for Harrier

Gyro characteristics for rapid gyrocompassing  
**FIAT S.P.A., TURIN (ITALY)**

Elastic-constant evaluation of a reinforced plastic material  
 Flat catalysts

An integral method for extraction of aerodynamic coefficients from large test data  
 A contribution to stress corrosion testing of aluminum alloys

**FIGHTER BOMBER WING (118), KERPER EFT (WEST GERMANY)**  
 Use of medication: Drugs especially abused by flying personnel

**FLORIDA UNIV., GAINESVILLE**  
 Preprocessing for pictorial pattern recognition  
 Normal limits for the sequential bimaternal natural casing test

**FLORIDA UNIV., PORT CANAVERAL**  
 Frequency correlation function for troposcatter circuits

**FLUGWISSENSCHAFTLICHE FORSCHUNGSANSTALT, MUNICH (WEST GERMANY)**  
 Breeding monkeys for biomedical research

**FLUGZEUGFUEHRERSCHULE KLEIN HEIDORN (WEST GERMANY)**  
 Translators and aviation

**FONDAZIONE UGO BORDONI, ROME (ITALY)**  
 Criteria and expected accuracy of the measurements envisaged in the research programme under way in Italy

Introductory survey to session 4: Propagation data for interference probability determinations  
**FORC'AL ISSOIRE (FRANCE)**

New basis of classification and selection of aluminum alloys  
**FORSCHUNGSINSTITUT FUER ANTHROPOTECHNIK, MECKENHEIM (WEST GERMANY)**

A symbol generator for the anthropotechnical evaluation of integrated displays  
 Pilot workload

**FORSCHUNGSINSTITUT FUER FUNK UND MATHEMATIK, WERTHOVEN (WEST GERMANY)**  
 Adaptive prewhitening filter

The use of target and clutter data for different methods of discrimination between targets and unwanted clutter

**FORSCHUNGSINSTITUT FUER HOCHFREQUENZPHYSIK, PORN (WEST GERMANY)**  
 Tropospheric path parameters with multiple access systems in space communications

VHF propagation measurements on a real 3-D troposcatter path  
 Calculating troposcatter interference distribution using a Monte Carlo method

**FORSCHUNGSINSTITUT FUER HOCHFREQUENZPHYSIK, WERTHOVEN (WEST GERMANY)**  
 Daily and hourly forecast of tropospheric propagation parameters

Short-term forecast of signal behaviour with tropospheric scatter links  
 Propagation effects on ionospheric emission in the stratosphere using scatter at appropriate frequencies

**FRANKFORD ARSENAL, PHILADELPHIA, PA.**  
 Tensile elongation stability and the growth of stress corrosion cracks in a homogeneous Xn Mg Cu aluminum alloy

**FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG E.V., KARLSRUHE (WEST GERMANY)**  
 Optical pattern processing for recognition

**FREIBURG UNIV. (WEST GERMANY)**  
 Numerical treatment of time dependent three dimensional flows

Self induction saturation pulse to modulate effects and motion on surface of a fluid by optimum stimulation

**FRENCH FLIGHT TEST CENTER, ISTRES**  
 Dynamic state processing systems

## G

**GAUSTAD MENTAL HOSPITAL, OSLO (NORWAY)**  
 Mental and physiological environmental requirements in married flight

**GEC MARCONI ELECTRONICS LTD., CHELMSFORD (ENGLAND)**  
 Troposcatter propagation in an equatorial climate

A computerized reliable ultrasonic termogalvanometer  
**GENERAL DYNAMICS AERONAUTICS, SAN DIEGO, CALIF.**

A survey of long range methods for 2D and 3D target tracking with radars  
**GENERAL DYNAMICS CONVAIR, SAN DIEGO, CALIF.**

Experimental results of high frequency radar clutter and wing geometry in a target  
 Target identification of passive radar systems

**GENERAL DYNAMICS FORT WORTH, TEX.**  
 Physics of the water-air interface of a high performance light test system

An aerodynamic study of jet engine nozzles  
 Comparisons in the stress field design process

Automated design in future design tools  
 A simplified mathematical model for the analysis of multilayered and anisotropic materials

Static and dynamic characteristics of a 1000 lb. aircraft  
**GENERAL ELECTRIC CO., CINCINNATI, OHIO**

A method for predicting interference forces and moments on aircraft in subsonic speeds  
 High temperature turbine design considerations

A frame propulsion system integration and thrust using the propulsion simulation technique  
 Lubricating oil interactions in advanced aircraft gas turbines

(NASA CR 122842)  
 Directionally solidified eutectics in gas turbine design

Technology for the reduction of aircraft engine engine exhaust emissions  
**GENERAL ELECTRIC CO., SYRACUSE, N.Y.**

Tropospheric effects on space communications  
 Signal analysis and classification by interactive computer graphics

Ionospheric refraction effect on the geometry of land aligned ionization  
**GEORGIA INST. OF TECH., ATLANTA**

A vortex analysis of a single bladed hovering rotor and a comparison with experimental data  
**GERMAN AIR FORCE, FORZ WAHN (WEST GERMANY)**

Physical understanding, training and forecast test of German Air Force aircraft  
 Technical evaluation report conclusion and recommendations

**GERMAN AIR FORCE, FORZ WAHN (WEST GERMANY)**  
 Physical understanding, training and forecast test of German Air Force aircraft

**GERMAN FEDERAL ARMED FORCES, BONN**  
 Technical evaluation report conclusion and recommendations

**GIRAVIONS DORAND CO., PARIS (FRANCE)**  
 Fields of application of jet-fueled turbines

**GOVERNMENT COMMUNICATIONS, MC CLELLANHAM (ENGLAND)**  
 The effect of ionospheric disturbances on the bearings of incoming sky waves

**GREATER LONDON COUNCIL (ENGLAND)**  
 Meteorological and topographic systems: A state of the art review

**GRUPE PECHINEY VOREPPE (FRANCE)**  
 Production of a semi-synthetic compounds by low pressure

**GRUMMAN AEROSPACE CORP., BETHPAGE, N.Y.**  
 High reliability design techniques applied to the lunar module

Methods of applying and controlling design reliability  
 The benefits of a totally integrated reliability test program

Establishing requirements for a flight environment in the airborne and space environments  
 Transonic aerodynamic characteristics and their evaluation

The influence of cost and technical risk on the design of the avionics system for the space shuttle  
 Application of a design analysis system to a space shuttle preliminary design

Re and failure considerations for tactical aircraft  
**HAMBURG UNIV. (WEST GERMANY)**

Propagation of 16 GHz and 17 GHz on a transhorizon path over sea  
 Direct influences on line of sight propagation

Observations with synchrotron offset beams on a 77 cm path at 1.8 and 2.4 cm  
 The state of radar clutter prediction over sea

Phase measurements with microwaves near the sea surface  
 Explanation of very low field strength levels on line of sight paths over sea

**HAWKER SIDDELEY AVIATION LTD., BROUGH (ENGLAND)**  
 Minicomputer aided trajectory computation: Development of the Hightech method

Extension of wind test range to 295 knots  
**HAWKER SIDDELEY AVIATION LTD., HATFIELD (ENGLAND)**

Aerodynamic and structural high lift devices  
 The flying of a 25 ft tip research aircraft

Human factors in low weather operations of a space aircraft  
 Use of wind tunnel and computer data for flight predictions for aircraft flying in complex roles

The HAFS FSOU cumulative damage hypothesis  
 Comparison with a more accurate cumulative damage model for aircraft certification

**HAWKER SIDDELEY AVIATION LTD., KINGSTON UPON THAMES (ENGLAND)**  
 On the possibility of detecting high Reynolds number flight test wing flow separation

**HAWKER SIDDELEY AVIATION LTD., KINGSTON UPON THAMES (ENGLAND)**  
 On the possibility of detecting high Reynolds number flight test wing flow separation

## ITALIAN AIR FORCE AEROSPACE MEDICAL CENTER, ROME

6 07 478 924 20

**ITALIAN AIR FORCE MEDICO-LEGAL INST. MILAN**  
Statistical survey on the clinical causes of temporary grounding and permanent disabilities of IAF aircrews.  
p0095 N72 14091

**ITALIAN AIR FORCE PSYCHO-PHYSIOLOGICAL INST. NAPLES**  
The psychophysical method in aviation psychology in the treatment of some syndromes of a reactive character.  
p0069 N71 20365

**ITT AVIONICS, NUTLEY, N.J.**  
Computers for inertial, C.D. and Omega navigation and guidance systems.  
p0177 N72 21225

**ITT GILFILLAN INC., VAN NUYS, CALIF.**  
The performance of the Oppenheim low-altitude tracking system in a multipath environment.  
p0234 N71 23706

J

**JOHANN WOLFGANG GOETHE UNIVERSITÄT FRANKFURT AM MAIN (WEST GERMANY)**  
The BiOSTACK experiment on Apollo 16.  
p0083 N73 23062

**JOHNS HOPKINS UNIV., BALTIMORE, MD**  
The structure of turbulence in shear flows.  
p0178 N72 20290

K

**KAMAN AEROSPACE CORP., BLOOMFIELD, CONN.**  
Rotary wing design methodology.  
p0056 N74 10909

**KANSAS UNIV., LAWRENCE**  
Radar imaging applications: Past, present and future.  
p0121 N72 16090

**KARLSRUHE UNIV. (WEST GERMANY)**  
Generation of line drawings from grey scale picture.  
p0155 N72 14705

**KARLSRUHE UNIV. (WEST GERMANY)**  
An analysis of multispectral imagery for tropical land discrimination.  
p0124 N72 16109

**KARLSRUHE UNIV. (WEST GERMANY)**  
The backscattering from two-scale rough surfaces.  
p0125 N72 16117

**KARLSRUHE UNIV. (WEST GERMANY)**  
Workshop on radar scattering held Tuesday afternoon 22 June 1971.  
p0126 N72 16119

**KARLSRUHE UNIV. (WEST GERMANY)**  
An actively variable lensed on the second principal invariant of the deformation tensor.  
p0126 N72 16280

**KIEL UNIV. (WEST GERMANY)**  
Present knowledge of cosmic rays.  
p0075 N72 26045

**KINGSTON UPON HULL CITY LIBRARIES, HULL (ENGLAND)**  
A computer-processed keyword indexing system for technical reports in the library of the British Research Association Limited.  
p0159 N74 16926

**KIRUNA GEOPHYSICAL OBSERVATORY (SWEDEN)**  
Polar propagation effects on radio astronomical and satellite measurements.  
p0128 N72 16137

**KIRUNA GEOPHYSICAL OBSERVATORY (SWEDEN)**  
Detection of 2 MHz radiation from moving auroral electrons.  
p0135 N73 14138

**KIRUNA GEOPHYSICAL OBSERVATORY (SWEDEN)**  
On the generation and detection of artificial atmospheric waves.  
p0138 N71 14161

**KLOCKNER HUMBOLDT DEUTZ A.G., OBERURSEL (WEST GERMANY)**  
Analysis of small gas turbine engine components.  
p0262 N71 26955

**KLOCKNER HUMBOLDT DEUTZ A.G., OBERURSEL (WEST GERMANY)**  
Auxiliary power units for secondary power systems.  
p0365 N71 19046

**KONGSBERG VAPENFABRIKK A.S. (NORWAY)**  
The analysis of a subsonic asymmetric inlet for compressor matching.  
p0267 N72 16714

L

**LABORATOIRE CENTRAL DE RECHERCHES THOMSON CSF, ORSAY (FRANCE)**  
Reduction of applied redundancy in the transmission of images.  
p0131 N73 10189

**LABORATOIRE CENTRAL DE RECHERCHES THOMSON CSF, ORSAY (FRANCE)**  
Integration of computer-aided functions, navigation, identification and traffic control.  
p0235 N73 23137

**LABORATOIRE CENTRAL DE RECHERCHES THOMSON CSF, ORSAY (FRANCE)**  
Synthesis of passive filters with finite attenuation points realized with weak noise components applied to high degree Cauchy filters.  
p0167 N74 13923

**LABORATOIRE CENTRAL DES INDUSTRIES ELECTRIQUES (FRANCE)**  
Application of superconductivity to high-voltage machines using liquid metals.  
p0064 N73 19117

**LABORATOIRE DE RECHERCHES BALISTIQUES ET AERODYNAMIQUES, VERNON (FRANCE)**  
Activities of CRBA in the next decade.  
p0231 N73 20114

**LABORATOIRE DE RECHERCHES BALISTIQUES ET AERODYNAMIQUES, VERNON (FRANCE)**  
Determination of a linear accelerometer by a method of differential tests.  
p0231 N73 20115

**PIGA, AERONAUTIC TESTS UNIVERSITY OF TRIESTE, ITALY**  
PIGA Aerodynamic tests university of Trieste, Italy.  
p0236 N74 14147

**PIGA, AERONAUTIC TESTS UNIVERSITY OF TRIESTE, ITALY**  
Measurement of drag in a shock tunnel.  
p0223 N74 14738

**LABORATOIRE UTAC, MONTLHERY (FRANCE)**  
Economic procedures for simulating the effects of linear collisions in view of studies of restraining devices for the protection of automobile occupants.  
p0098 N72 19122

**LABORATOIRES D'ELECTRONIQUE ET DE PHYSIQUE APPLIQUEE, PARIS, LIMEL, BREVANES (FRANCE)**  
Fundamental and practical limits of remote-initiated imaging instruments operating between 2.5 and 10 microns.  
p0123 N72 16134

**LABORATORIUM FUER BETRIEBSSTIGKEIT DARMSTADT (WEST GERMANY)**  
A relation between measured center of gravity vertical acceleration and the topics at the limit of a military engine.  
p0291 N73 16934

**LABORATORIUM FUER BETRIEBSSTIGKEIT DARMSTADT (WEST GERMANY)**  
Methods of stress measurement analysis for fatigue life evaluation.  
p0294 N73 29926

**LAMONT DOHERTY GEOLOGICAL OBSERVATORY, PALISADES, N.Y.**  
Acoustic gravity waves in the neutral atmosphere and the ionosphere.  
p0135 N73 14140

**LAVAL UNIV. (QUEBEC)**  
The approximation of Navier-Stokes equations for incompressible fluids.  
p0181 N72 27297

**LAVAL UNIV. (QUEBEC)**  
Numerical solution of steady-state Navier-Stokes equations.  
p0181 N72 27298

**LEAR SIEGLER INC., GRAND RAPIDS, MICH.**  
Raman filtering for rapid and accurate detection of CW interference on digital telecommunications.  
p0133 N73 10210

**LEEDS UNIV. (ENGLAND)**  
The scientific committee conference on the theory of stress corrosion cracking of alloys.  
p0286 N72 21907

**LEEDS UNIV. (ENGLAND)**  
Factors contributing to motion sickness susceptibility: Adaptability and acclimatization.  
p0078 N73 21095

**LILLE UNIV. (FRANCE)**  
Analysis of radiometrically induced sea temperature measurement.  
p0124 N72 16135

**LILLE UNIV. (FRANCE)**  
Analysis of radiometrically induced sea temperature measurement.  
p0124 N72 16136

**LINCOLN LAB., MASS. INST. OF TECH., LEXINGTON**  
The use of visible light scattering in long-range detection systems.  
p0192 N72 19100

**LINCOLN LAB., MASS. INST. OF TECH., LEXINGTON**  
A variable coverage satellite antenna system.  
p0193 N72 19507

**LINCOLN LAB., MASS. INST. OF TECH., LEXINGTON**  
Efficient X-band power generation for satellite communications.  
p0194 N72 19511

**LINCOLN LAB., MASS. INST. OF TECH., LEXINGTON**  
Some properties of radar altimeter waves as observed at a frequency of 1295 MHz.  
p0194 N72 19510

**LITTON SYSTEMS INC., VAN NUYS, CALIF.**  
The integrated cockpit procedure for identifying control and display requirements of aircraft in advanced time periods.  
p0223 N72 22625

**LITTON SYSTEMS INC., WOODLAND HILLS, CALIF.**  
Integrated inertial navigation computer guidance and control.  
p0157 N72 21224

**LITTON SYSTEMS INC., WOODLAND HILLS, CALIF.**  
A low-cost IMU resulting from optimum size design.  
p0228 N73 20690

**LITTON SYSTEMS INC., WOODLAND HILLS, CALIF.**  
Airborne area navigation equipment.  
p0233 N73 23698

**LIVERPOOL UNIV. (ENGLAND)**  
The application of multicomponent diffusion theory to the oxidation and corrosion of complex superalloys.  
p0202 N73 23679

**LIVERPOOL UNIV. (ENGLAND)**  
Are there new approaches to alloying which may produce oxidation-resistant refractory metal alloys?  
p0203 N73 23615

**LIVERPOOL UNIV. (ENGLAND)**  
Structural design applications of geometric programming.  
p0296 N74 15691

**LOCKHEED ELECTRONICS CO., WEST LONG BEACH, N.J.**  
Statistical propagation model for irregular terrain paths between transmittable and mobile terminals.  
p0170 N71 23475

**LOCKHEED CALIFORNIA CO., BURBANK**  
Experimental techniques used to study stress corrosion mechanisms in aircraft structural alloys.  
p0289 N72 21928

**LOCKHEED CALIFORNIA CO., BURBANK**  
Correlation of some fatigue failures in large fan engine ducts with computed theory.  
p0293 N73 29916

**LOCKHEED GEORGIA CO., MARIETTA**  
Comparing the properties of a system for a single SIFT and a system for a multiple SIFT system.  
p0221 N73 20063

**LOCKHEED GEORGIA CO., MARIETTA**  
Simulation of full-scale flight results and analysis of test results in existing transonic wind tunnels.  
p0014 N71 11873

**LOCKHEED GEORGIA CO., MARIETTA**  
A survey of drag prediction techniques applicable to subsonic and transonic aircraft design.  
p0019 N74 14711

**LONDON UNIV. (ENGLAND)**  
Sound fields generated by transonic flows over surfaces having complex perforated inlets.  
p0114 N72 11876

**LONDON UNIV. (ENGLAND)**  
Criteria for stable and post-stable equilibria.  
p0239 N72 32029

**LOUGHBOROUGH UNIV. OF TECHNOLOGY (ENGLAND)**  
Measurement of force responses during jumps.  
p0192 N72 19145

**LOUGHBOROUGH UNIV. OF TECHNOLOGY (ENGLAND)**  
Fundamental limitations of Navier-Stokes equations for wings.  
p0052 N73 21013

**LOUGHBOROUGH UNIV. OF TECHNOLOGY (ENGLAND)**  
Mathematical analysis of the flow and methods of reduction.  
p0012 N73 22453

**LOUISIANA STATE UNIV., BATON ROUGE**  
Control of frequency curves of the Danube River in Paris.  
p0122 N72 16093

**LOUVAIN UNIV. (BELGIUM)**  
Mechanical properties of epoxy silica composite materials.  
p0207 N72 12493

**LOUVAIN UNIV. (BELGIUM)**  
Passive and semi-active attitude stabilizations. Dual spin satellites.  
p0277 N72 12864

**LOUVAIN UNIV. (BELGIUM)**  
Effects due to precipitation on non-intellects at 12 and 35 GHz.  
p0141 N73 26130

**LOUVAIN UNIV. (BELGIUM)**  
Synthesis of aperture distributions for optimum gain with noise and interference rejection.  
p0147 N74 13880

**LOUVAIN UNIV. (BELGIUM)**  
The use of the transistor simulation program SITCAP for statistical modeling of bipolar transistors.  
p0165 N74 13913

**LOVELACE FOUNDATION FOR MEDICAL EDUCATION AND RESEARCH, ALBUQUERQUE, N.MEX.**  
The biodynamics of an blast.  
p0100 N72 19134

**LTV AEROSPACE CORP., DALLAS, TEX.**  
Vectorized thrust in air combat.  
p0264 N72 16694

**LTV AEROSPACE CORP., DALLAS, TEX.**  
A 7 aircraft airborne ground and shipboard maneuvering algorithm methodology and results.  
p0231 N73 20710

**LTV AEROSPACE CORP., DALLAS, TEX.**  
Prediction of buffet onset for aircraft recent progress in wind tunnel and flight test data correlation.  
p0071 N74 14725

**LUCAS GAS TURBINE EQUIPMENT LTD., LURNLEY (ENGLAND)**  
Fuel related problems in aircraft fuel systems.  
p0252 N72 11617

**LUDWIG MAXIMILIANS UNIVERSITÄT, MUNICH (WEST GERMANY)**  
Thermoelectric stimulation of the labyrinth.  
p0109 N74 20748

**LUND UNIV. (SWEDEN)**  
Effects of increased middle ear pressure on the vestibular system.  
p0110 N74 20755

**LYON UNIV. (FRANCE)**  
Development of a turbulent boundary layer on a flat plate in an external turbulent flow.  
p0180 N72 20306

M

**M. L. AVIATION CO. LTD., MAIDENHEAD (ENGLAND)**  
The design and development testing of aircrew protective helmets.  
p0106 N72 19162

**MAGNAVOX RESEARCH LABS., TORRANCE, CALIF.**  
Spread spectrum applications and state of the art.  
p0143 N73 32058

**MAGNETIC CORP. OF AMERICA, CAMBRIDGE, MASS.**  
Superconductivity in steady state and pulsed applications for flight vehicles.  
p0063 N73 19031

**MAGNETIC CORP. OF AMERICA, CAMBRIDGE, MASS.**  
Superconducting generators.  
p0064 N73 19039

**MAINTZ UNIV. (WEST GERMANY)**  
Usage and performance.  
p0081 N72 21115

**MAINTZ UNIV. (WEST GERMANY)**  
Human eye movements during various forms of linear acceleration and weightlessness.  
p0109 N74 20747

**MANCHESTER UNIV. (ENGLAND)**  
Digital communications theory.  
p0143 N73 32055

**MANUFACTURE BELGE DE LAMPES ET DE MATERIEL ELECTRONIQUE, BRUXELLES (BELGIUM)**  
A general model: Minkowski metric pattern classifier.  
p0153 N72 11191

**MARCONI CO. LTD., GREAT BADDOW (ENGLAND)**  
Ave diversity applied to tropospheric scatter systems.  
p0118 N71 23459

**MARCONI SPACE AND DEFENCE SYSTEMS LTD., PRIMLEY (ENGLAND)**  
Methods of identification of the earth horizon and examples of application to attitude determination of spacecraft.  
p0192 N72 19495

**MARCONI SPACE AND DEFENCE SYSTEMS LTD., PRIMLEY (ENGLAND)**  
Use of computers for real time satellite checkout.  
p0193 N72 19501

**MARCONI ELLIOTT AVIONIC SYSTEMS LTD., ROCHESTER (ENGLAND)**  
The use of a cluster rotated inertial system in a strike aircraft environment.  
p0230 N73 20704

**MARCONI ELLIOTT AVIONIC SYSTEMS LTD., ROCHESTER (ENGLAND)**  
Development of aircraft digital systems.  
p0281 N73 23900

**MARINE AIRCRAFT WING (2D), CHERRY POINT, N.C.**  
AV-8A Harrier concept and operational performance in US Marine Corps.  
p0054 N73 27005

**MARTIN MARIETTA CORP., ORLANDO, FLA.**  
Correlation bandwidth measurements over tropospheric paths.  
p0119 N71 23465

**MARTIN MARIETTA CORP., ORLANDO, FLA.**  
Generalized lateral motion guidance and control techniques.  
p0226 N72 27682

**MARTIN MARIETTA CORP., ORLANDO, FLA.**  
Laboratory techniques and evaluation methodology.  
p0221 N72 27688

**MASSACHUSETTS INST. OF TECH., CAMBRIDGE**  
Altitude control of the Apollo spacecraft.  
p0279 N72 12879

**MASSACHUSETTS INST. OF TECH., CAMBRIDGE**  
An experimental test of a test system.  
p0157 N72 27169

**MASSACHUSETTS INST. OF TECH., CAMBRIDGE**  
Integrated theory principles and some applications to a SIFT aircraft.  
p0224 N72 22639

**MASSACHUSETTS INST. OF TECH., CAMBRIDGE**  
A model for a surface gravity wave excited by a randomly moving and reflecting mass.  
p0133 N73 14135

**MASSACHUSETTS INST. OF TECH., CAMBRIDGE**  
Exposure estimation of Earth's atmosphere to cosmic rays.  
p0136 N73 14143

**MASSACHUSETTS INST. OF TECH., CAMBRIDGE**  
The interaction of atmospheric ionospheric layers with the ionosphere.  
p0136 N73 14144

Summary of new developments at the Graper Laboratory  
p0227 N73 20686

Feature management of multiple orbital inertial systems for space shuttle  
p0228 N73 20687

Strap-on inertial gyroscope  
p0228 N73 20688

Inertial gyro testing for reliability  
p0228 N73 20689

Man's role in integrated control and information management systems  
p0278 N73 23882

A review of past AGARD NATO actions on V-STOL aircraft and their applications  
p0054 N73 21001

Soot oxidation kinetics at combustion temperatures  
p0219 N74 14290

Parameters controlling nitric oxide emissions from gas turbine combustors  
p0218 N74 14291

Automated myogram analysis  
p0110 N74 20751

**MATERIALS SCIENCES CORP. BLUE BELL PA**  
Design of composite materials  
p0209 N72 20590

**MATRIX CORP. ALEXANDRIA VA**  
Flight crew adaptability to the helicopter vibration environment  
p0088 N71 20355

**MAX PLANCK INSTITUT FUER AERONOMIE, LINDAU UBER NORDHEIM (WEST GERMANY)**  
Influence of the troposphere on low incident satellite signals in the range of wavelength 5 to 2 m  
p0115 N71 21420

An application of the Monte Carlo method to remote sensing systems  
p0125 N72 18115

Current experimental results from a VHF CW auroral backscatter network in Scandinavia  
p0127 N72 21128

Satellite scintillation between 43 deg and 48 deg northern latitude from 1964 to 1969  
p0128 N72 21147

Polar propagation effects on HF radars  
p0128 N72 21142

Full wave calculations of electron density perturbations caused by atmospheric gravity waves in the F2 layer  
p0138 N73 14145

A phenomenological investigation of amplitudes and spectra of gravity waves  
p0137 N73 14149

Some effects of atmospheric gravity waves observed on a transatlantic radio path  
p0139 N73 14184

**MAX PLANCK INSTITUT FUER ARBEITSPHYSIK/LOHIE DORTMUND (WEST GERMANY)**  
An electrohydraulic system for simulations of collisions  
p0103 N72 19157

Severe frontal collisions and resulting injuries with and without restraining devices  
p0104 N72 19159

**MAX PLANCK INSTITUT FUER PHYSIKALISCHE CHEMIE, GOTTINGEN (WEST GERMANY)**  
General aspects of high temperature corrosion of structural materials  
p0201 N73 23598

**MAX PLANCK INSTITUT FUER PLASMAPHYSIK, GARCHING (WEST GERMANY)**  
Use of superconductors for pulsed experiments in plasma physics  
p0063 N73 19033

**MAX PLANCK INSTITUT FUER PLASMAPHYSIK, MUNICH (WEST GERMANY)**  
Laser A light source for high speed photography  
p0200 N72 25504

**MAYO CLINIC, ROCHESTER, MINN**  
Effects of positive G<sub>y</sub> acceleration on blood oxygen saturation and pleural pressure relationships in dogs breathing first air then liquid fluorocarbon in a whole body water immersion respirator  
[NASA CR 117199]  
p0068 N71 20358

**MCDONNELL AIRCRAFT CO. ST LOUIS MO**  
Evaluation of the prediction of airplane store interference by linear theory  
p0005 N71 19381

Techniques of system reliability estimation including failure effect analysis failure consequences  
p0189 N71 36177

Effectiveness of reliability program elements  
p0189 N71 36179

System response considerations and their relationship to the test process  
p0190 N71 36185

Structural fatigue analysis and testing for fighter aircraft  
p0060 N74 19855

**MCDONNELL DOUGLAS AERONAUTICS CO., HUNTINGTON BEACH CALIF**  
Adjoint solutions for intercept guidance  
p0278 N72 27684  
p0276 N72 27685  
p0276 N72 27686

Optimization  
p0276 N72 27684

Kalman filter  
p0276 N72 27686

**MCILL UNIV. MONTREAL (QUEBEC)**  
Application of weather radar data to propagation questions  
p0114 N71 21416

Rain attenuation statistics for frequency above 10 GHz from rain gauge records  
p0142 N73 26135

Nystagmography: A useful tool in basic and applied investigations  
p0108 N74 20141

**MESSERSCHMITT BOELKOW GMBH MUNICH (WEST GERMANY)**  
Downwash investigations on tails of aircraft  
p0092 N71 19160

V-STOL accidents in the Netherlands  
p0030 N71 23428

Pulse jet engine as a source of energy for auxiliary power units  
p0065 N73 19147

**MESSERSCHMITT BOELKOW GMBH OTTOBRUNN (WEST GERMANY)**  
Influence of turbulence on helicopter design and flight  
p0159 N74 17736

**MESSERSCHMITT BOELKOW BLOHM GMBH HAMBURG (WEST GERMANY)**  
Optimization and design of the rear fuselage of the A 300 B aircraft structure  
p0298 N74 15614

**MESSERSCHMITT BOELKOW BLOHM GMBH MUNICH (WEST GERMANY)**  
Operational proving of automatic flight control systems for V-STOL fighter aircraft  
p0028 N71 23415

Some recent investigations on flutter in subsonic flow caused by interference aerodynamic forces between wing and tail of a variable geometry aircraft  
p0009 N71 28345

Wind tunnel investigations of a subsonic air intake with various auxiliary intakes at low speeds  
p0267 N72 18718

Electronic of a mass spectrometer  
p0192 N72 19494

Satellite television system  
p0192 N72 19498

A method of man display control system evaluation  
p0224 N72 22629

Nozzle-airframe interference and integration  
p0037 N72 20720

V-STOL handling qualities criteria compared with flight test results of the V-STOL supersonic fighter VJ 101C and the V-STOL transport aircraft DO 31E  
p0039 N72 22024

Impact of new technology as illustrated in an advanced operational data system  
p0195 N73 10457

**MESSERSCHMITT BOELKOW BLOHM GMBH OTTOBRUNN (WEST GERMANY)**  
Optimization of automatic flight control concepts for light helicopters with all weather capability  
p0030 N72 11917

Powered controls influence on stability and maneuverability  
p0045 N73 17038

Influence of elastic coupling effects on the handling qualities of a hingeless rotor helicopter  
p0047 N73 21016

Some aspects of the design of rotor-airfoil shapes  
p0051 N73 21045

Some objectives in applying hingeless rotors to helicopters and V-STOL aircraft  
p0051 N73 21051

Basic dynamics of rotors: control and stability of rotary wing aircraft  
p0051 N73 21051

Aerodynamics and dynamics of advanced rotary wing configurations  
p0017 N73 22951

Parameter trends and optimization preliminary selection of configuration prototype design and manufacture  
p0018 N73 22958

Application of composite materials for aerospace structures  
p0211 N73 27482

Loads prediction methods for hingeless rotor helicopters  
p0058 N74 10915

Problems of estimating the drag of a helicopter  
p0019 N74 14715

**METEOROLOGICAL OFFICE BRACKNELL (ENGLAND)**  
Turbulence at medium and high flight levels  
p0057 N74 17721

**METEOROLOGICAL OFFICE (OT BRIT)**  
Nitrogen oxides nuclear weapon testing: concorde and stratospheric ozone  
p0217 N74 14275

**MIAMI UNIV. OXFORD OHIO**  
Effects of sound on the vestibular system  
p0109 N74 20745

**MICHIGAN STATE UNIV. EAST LANSING**  
Controllability and solvability of the wave propagation in inhomogeneities  
p0119 N71 23562

Turbulence and reliability changes and their sensing based upon the wave mechanics theory  
p0125 N72 16116

**MICHIGAN UNIV. ANN ARBOR**  
Maneuverability of extreme for wings in free fall  
p0099 N72 19125

Biomechanics of restraint and impact attenuation systems  
p0123 N72 19156

The biomechanics aspects of crash helmet design  
p0104 N72 19161

Structure of the Reynolds stress near the wall  
p0175 N72 20275

Experimental radiography  
p0199 N72 25499

Charge transfer of diatomic ions  
p0199 N72 25500

**MIDDLE EAST TECHNICAL UNIV. ANKARA (TURKEY)**  
Application of discriminant function to the pattern recognition  
p0246 N74 15603

**MIDWEST RESEARCH INST. KANSAS CITY MO**  
Mechanisms of fatigue crack growth in steel and metals  
p0208 N72 12514

**MILITARY SCHOOL OF AVIATION MEDICINE ROME (ITALY)**  
Biodynamics for the NATO E-type aircraft  
p0195 N71 21411

**MINISTRY OF DEFENCE (WEST GERMANY)**  
The helicopter rotor: A concept for a new rotor  
p0115 N74 21616

**MINISTRY OF DEFENCE (LONDON (ENGLAND))**  
A study of the Royal Air Force's new aircraft from the first 18 months  
p0129 N71 23427

V-STOL concepts for approach and landing  
p0224 N72 22632

Design of a helicopter rotor for high speed flight  
p0192 N73 24041

Experimental investigation of the V-Dynamics Panel  
p0192 N73 24041

Speech and Hearing in Aircraft and Helicopters  
p0018 N74 10915

Technical investigation report  
p0019 N74 14719

The performance of aircraft systems with the pilot in the loop  
p0175 N74 21615

**MINISTRY OF EDUCATION AND SCIENCES DOCUMENTATION DEPARTMENT THE HAGUE (NETHERLANDS)**  
Training of personnel to man the various parts of an information centre and to operate various kinds of service  
p0158 N73 24205

**MINISTRY OF TECHNOLOGY, LONDON (ENGLAND)**  
Weather as a factor in fatal accidents involving civil transport aircraft  
p0030 N71 23431

**MINISTRY OF TECHNOLOGY, ORPINGTON (ENGLAND)**  
Selective dissemination of information: A systems review  
p0301 N71 23506

**MINNESOTA UNIV. MINNEAPOLIS**  
Film coupling with hypson through holes  
[NASA CR 116376]  
p0259 N71 17388

Practical problems in clinical nystagmography  
p0108 N74 20734

Guidelines for selection of equipment  
p0108 N74 20734

**MISSISSIPPI STATE UNIV. STATE COLLEGE**  
The handling qualities required for safe operation of single engine boundary layer controlled aircraft in the STOL mode  
p0028 N71 23419

**MITRE CORP. BEDFORD MASS**  
A flexible hardware fast Fourier transform digital processor  
p0132 N73 10198

Derivation of a wide area position location capability using a synchroded time division multiple access communication system  
p0234 N73 23711

A practical design of an ICDI system  
p0236 N73 23720

Propagation of 15.6, 31.2 GHz and 45, 90 GHz coherent signals  
p0141 N73 26131

**MONSANTO RESEARCH CORP. DAYTON OHIO**  
Application of analytical techniques for the analysis of additives and contaminants in advanced hydrocarbon fuels  
p0251 N72 11673

**MONTECATINI EDISON S.P.A. MILAN (ITALY)**  
Integrated check out system for space launchers and aircraft systems  
p0191 N72 19489

Considerations on a subsystem for handling commands and stimuli for an integrated and automatic check out of space launchers  
p0191 N72 19490

**MOTOR INDUSTRY RESEARCH ASSOCIATION, LINDLEY (ENGLAND)**  
The MIRA vehicle impact test facility  
p0103 N72 19154

**MOTOREN- UND TURBINEN UNION MUENCHEN GMBH (WEST GERMANY)**  
Erosion: Coring of turbine blades  
p0258 N71 17382

Aerodynamics of thrust reverser design  
p0204 N72 16659

Extraction of auxiliary power from a breathing apparatus systems  
p0065 N73 19053

An analytical approach to the loss and reflection of waves in a transition flow including axial mass flow  
p0268 N73 19800

The influence of gas property density ratio on pressure cascade performance in compressible flow  
p0269 N73 19805

A calculation method for the external heat transfer to turbine blades  
p0269 N73 19807

Experiments with a directional solidification. Study on the application to turbine blades  
p0213 N73 21494

Exhaust emission measurement results on the GE T64-2 turbojet engine  
p0219 N74 14286

**MOTOROLA INC. PHOENIX ARIZ**  
A computer-aided design system for large scale integrated digital networks  
p0168 N74 13933

**MOTOROLA INC. SCOTTSDALE ARIZ**  
A true 3D on par 2D display  
p0225 N72 22640

**MOUNT AUBURN RESEARCH ASSOCIATES INC. NEWTON UPPER FALLS MASS**  
Monitoring of nuclear reactors of acoustic quality  
p0135 N73 14141

**MOUNT SINAI MEDICAL AND GRADUATE SCHOOLS, NEW YORK**  
Visual vestibular interaction: The use of the labyrinth in the production of optokinetic nystagmus and optokinetic after-nystagmus  
p0109 N74 20743

**MULLARD RADIO VALVE CO. LTD. RED HILL (ENGLAND)**  
Design and evaluation of a helicopter guidance aid  
p0034 N72 11936

**MULLARD RESEARCH LABS. SALFORDS (ENGLAND)**  
A review of workers' views on the future of automatic machine tools  
p0161 N74 16938

## N

**NANCY UNIV. (FRANCE)**  
What are the prospects for the successful application of automated laboratory methods in medical diagnosis?  
p0201 N73 21614

**NAPLES UNIV. (ITALY)**  
Production of fibrous metal composites by powder metallurgy  
p0210 N73 27478

**NATIONAAL LUCHT-EN RUIMTEVAARTLABORATORIUM, AMSTERDAM (NETHERLANDS)**  
Some notes on two dimensional high speed tests in wind tunnels  
p0025 N71 20056

Minimum required measuring times to perform stationary measurements in transition wind tunnels  
p0173 N73 26243

**NATIONAL AERO- AND ASTRONAUTICAL RESEARCH INST., AMSTERDAM (NETHERLANDS)**

Men machine combination in the light of safety requirements p0029 N71 23473  
Unsteady aerodynamics for wings with control surfaces p0009 N71 29346  
Some considerations of future low speed tunnels for Europe p0173 N74 16988  
Re assessment of fatigue performance of lighter aircraft p0061 N74 19659

**NATIONAL AERONAUTICAL ESTABLISHMENT, OTTAWA (ONTARIO)**

The half cone pressure field and its significance to side mounted intakes p0003 N71 19367  
Review of several factors relevant to jet upsets p0029 N71 23424  
The transonic performance of two dimensional jet flapped airfoils at high Reynolds numbers p0012 N72 11861  
Comparisons between some high Reynolds number turbulent boundary layer experiments at Mach 4 and various recent calculation procedures p0177 N72 20289  
Parameters affecting lateral directional handling qualities at low speeds p0040 N72 32033  
Surface pressure fluctuations from jet impingement on an inclined flat plate p0192 N73 2990  
Drag of supercritical airfoils in transonic flow p0020 N74 14719  
The drag resulting from three dimensional separations caused by boundary layer diverters and nacelles in subsonic and supersonic flow p0021 N74 14728  
Turbulence and mesoscale horizontal temperature gradients in the lower stratosphere p0057 N74 17723

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AMES RESEARCH CENTER, MOFFETT FIELD, CALIF.**

Pilot assessment aspects of simulation p0172 N71 16069  
Recent experience in using finite element methods for the solution of problems in aerodynamic interference [NASA TM X 66884] p0001 N71 19357  
Studies of aircraft flow fields at inlet locations [NASA TM X 66885] p0004 N71 19371  
Volitional control of visual accommodation [NASA TM X 66955] p0070 N71 20371  
Feasibility of testing a large chord swept panel model to determine wing shock location at flight Reynolds number [NASA TM X 67414] p0013 N72 11879  
Transonic testing in existing wind tunnels p0014 N72 11872  
On the use of free-12 for increasing Reynolds number in wind tunnel testing of three dimensional aircraft models at subcritical and supercritical Mach numbers [NASA TM X 67417] p0015 N72 11879  
Some important considerations in the development of stress corrosion cracking test methods [NASA TM X 68303] p0283 N72 21905  
Revisions to V-STOL handling qualities criteria of AGARD report 408 p0038 N72 32021  
Considerations for stability and control of V-STOL aircraft: A review of AGARD report 577 p0044 N73 16994  
A summary of wind tunnel research on the effects of hover to cruise flight p0051 N73 21049  
Responses of blind fish to gravitational change, as achieved in parabolic flight p0079 N73 21101  
The development and use of a modern data bank p0159 N73 24212  
Pressure fluctuation inputs and response of panels underlying attached and separated supersonic turbulent boundary layers p0292 N73 29910  
Survey of computational methods for three dimensional supersonic inviscid flows with shocks p0185 N74 22919

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FLIGHT RESEARCH CENTER, EDWARDS, CALIF.**

A comparison of some aerodynamic drag factors as determined in full scale flight with wind tunnel and theoretical results [NASA TM X 67413] p0013 N72 11869  
A flight investigation of steady state and dynamic pressure phenomena in the vicinity of supersonic aircraft [NASA TM X 67495] p0266 N72 16709  
Techniques for the evaluation of air breathing propulsion systems: full scale flight p0035 N72 20983  
Lifting body flight test techniques p0035 N72 20986  
Flight test experience in aircraft parameter identification p0046 N73 17012  
Review of drag measurements from flight tests of manned aircraft with comparisons to wind tunnel predictions p0072 N74 14735

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER, GREENBELT, MD**

Spacecraft attitude sensors with emphasis on the utility of astronomical observations [NASA TM X 67384] p0077 N72 12863  
Microstructure of radio plasma instabilities p0077 N72 12863  
Microstructure of radio plasma instabilities p0077 N72 12863

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LANGLEY RESEARCH CENTER, LANGLEY STATION, VA**

Extension of a numerical solution for the aerodynamic characteristics of a wing to include a canard or horizontal tail [NASA TM X 66886] p0002 N71 19361  
Aerodynamic interference between exhaust system and airframe [NASA TM X 66988] p0003 N71 19368  
Reynolds number requirements for valid testing at transonic speeds [NASA TM X 67412] p0012 N72 11851  
Transonic free flight model testing at large scale [NASA TM X 67416] p0015 N72 11878  
A facility concept for high Reynolds number testing at transonic speeds [NASA TM X 67418] p0015 N72 11880  
Hot salt stress corrosion cracking of titanium alloys: Overview and impact on space shuttle application [NASA TM X 68304] p0289 N72 21926  
Maneuver and buffet characteristics of fighter aircraft p0043 N73 15019

Active control of aeroblastic response p0045 N73 17005  
A summary of current research in rotor unsteady aerodynamics with emphasis on work at Langley Research Center p0050 N73 21041  
A compressible unsteady theory for helicopter rotors p0050 N73 21044  
An analysis of aerodynamic structural coupling and flow control techniques p0233 N73 23701  
Application of composite materials to the selective reinforcement of metallic aerospace structures p0111 N73 27485  
Dynamic loading of aircraft tail fins due to jet exhaust impingement p0292 N73 29908  
Automated sizing of large structures by mixed optimization methods p0297 N74 15611  
Vortex wake research p0058 N74 17733  
Theoretical horizontal tail loads and associated aircraft responses of an aircraft in induced jet transport flying in turbulence p0059 N74 17742  
Comments on NASA Langley research on transonic unsteady aerodynamics [NASA TM X 69997] p0023 N74 18652

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LEWIS RESEARCH CENTER, CLEVELAND, OHIO**

Turbine engine: its limitations and its future [NASA TM X 66702] p0258 N71 17385  
Flight and wind tunnel investigation of installation effects on underwing supercritical cruise exhaust nozzles at transonic speeds [NASA TM X 66887] p0003 N71 19366  
High temperature turbines p0261 N71 22699  
Inlet engine nozzle wind tunnel test techniques [NASA TM X 67123] p0263 N72 16692  
Technical evaluation report on Propulsors and Energetics Panel 38th Meeting on Inlets and Nozzles for Aerospace Engines [NASA TM X 67741] p0267 N72 21819  
Factors affecting the efficiency and cost utilization of high power transmission satellite systems p0134 N73 10205  
Engine selection for transport and combat aircraft p0053 N73 24048  
Material and structural studies of metal and polymer matrix composites p0212 N73 27491  
Design and installation of combustors for reducing aircraft engine pollution p0221 N74 14302

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDOX B JOHNSON SPACE CENTER, HOUSTON, TEX.**

Infrared and multispectral remote sensing [NASA TM X 67496] p0123 N72 16103  
Visual phenomena induced by cosmic rays and accelerated particles [NASA TM X 68460] p0075 N72 26051  
Systems performance monitoring for advanced manned spacecraft p0280 N73 23893

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.**

MSFC high Reynolds number tube tunnel [NASA TM X 67119] p0015 N72 11882  
Progress in strapdown technology p0279 N73 20699  
Optimum spaceborne computer system design by simulation p0279 N73 23891  
The NASA computer aided design and test system p0158 N74 13931  
Problems in the simulation of atmospheric boundary layer flows p0057 N74 17722

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.**

Vibration in V-STOL aircraft [NASA TM X 66956] p0068 N71 20356  
Rheodynamics bibliography, 1966-1969 p0095 N71 23344  
Avoidance of aircraft trailing vortex hazards [NASA TM X 67125] p0028 N73 23419  
Thrust vectoring [NASA TM X 67142] p0031 N71 23514  
A simplified space technology method for aircraft crew escape and exit from respiratory system [NASA TM X 68170] p0074 N72 25097

Recent NASA handling qualities research p0040 N72 32038  
Recent NASA aerospace medicine technology developments p0083 N73 23058  
The environment and materials for glide recovery vehicles p0201 N73 23801  
Potential teleoperator applications in manned aerospace systems p0281 N73 23904  
NASA propulsive lift STOL technology program p0055 N73 27009

**NATIONAL AERONAUTICS AND SPACE COUNCIL, WASHINGTON, D.C.**

A review of V-STOL aircraft accidents in the US p0029 N71 23426

**NATIONAL AEROSPACE LAB., AMSTERDAM (NETHERLANDS)**

An approximate method for the calculation of the pressure distribution on wing body combinations at subcritical speeds p0003 N71 19364  
Operational flight recording and its impact on flight safety and aircraft design p0027 N71 23412  
Introductory paper p0301 N71 23502  
Sources of scientific and technological information p0301 N71 23505

Inlets airplane testing in transonic wind tunnels p0263 N72 16687

A calculation method for three dimensional incompressible turbulent boundary layers p0177 N72 20285

Experimental determination of nozzle characteristics and nozzle airframe interference p0037 N72 27021  
Comments on the methods developed at NLR for conducting two dimensional research on high lift devices p0042 N73 15005

The accumulation of fatigue damage in aircraft materials and structures p0291 N73 16899

Effects of test frequency on fatigue crack propagation under high speed loading p0291 N73 16900

Summary of AGARD meeting on Problems of the Cockpit Environment, November 1968 in Amsterdam, Netherlands p0044 N73 16930

ATC automation: present and future p0232 N73 23693  
Aspects of aeronautical fatigue p0234 N73 29925

Comparison of various methods for calculating profile drag from pressure measurements in the near wake at subcritical speeds p0020 N74 14721

Facilities for aerodynamic testing at hypersonic speeds p0174 N74 15993

Technical and operational aspects of externally mounted aircraft equipment p0305 N74 21614

**NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER, ATLANTIC CITY, N.J.**

Crash safe turbine fuel development by the Federal Aviation Administration, 1964-1970 p0253 N72 11687

**NATIONAL BUREAU OF STANDARDS, WASHINGTON, D.C.**

The mathematics of impact and crash tests of airplane airbag restraint systems p0103 N72 19155

Generation and propagation of sound waves between the troposphere and the lower atmosphere p0134 N73 14134

**NATIONAL DEFENCE MEDICAL CENTRE, OTTAWA (ONTARIO)**

Colour vision in the Canadian Armed Forces p0077 N73 19070

**NATIONAL ENGINEERING LAB., EAST KILBRIDE (SCOTLAND)**

Industrial heat exchangers p0299 N72 18949

**NATIONAL ENVIRONMENTAL SATELLITE CENTER, WASHINGTON, D.C.**

Factors affecting the accuracy of sea surface temperature measurements fromITOS SR data p0124 N72 16107

**NATIONAL GAS TURBINE ESTABLISHMENT, FARNBOROUGH (ENGLAND)**

Measurement full scale of propeller noise performance in an altitude test facility p0263 N72 16691

**NATIONAL GAS TURBINE ESTABLISHMENT, PLYSTOCK (ENGLAND)**

Heat transfer calculations for turbine blade design p0257 N71 17374

Fibre strengthened metal base alloy p0259 N71 17392  
Some mechanical design problems of turbine blades and discs p0261 N71 17401

Some recent research on supersonic intakes at NGL p0004 N71 19372

Free jet tests of a full scale supersonic intake engine combination p0265 N72 16701

Performance of boundary layer transition on turbine compressor blades p0269 N73 19197

The environment encountered by high temperature components of the aircraft gas turbine p0201 N73 23593

A literature review of the application of advanced fibrous composites to aircraft engine components p0212 N73 1499

Soil formation in high pressure tanks at high pressure p0274 N74 14289

**NATIONAL INSTITUTES OF HEALTH, BETHESDA, MD**

Production of the first human embryo in vitro p0099 N72 19121

# CORPORATE SOURCE INDEX

## NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION BOULDER, COLO.

Some analogies between the propagation of ionospheric radio waves and acoustic gravity waves p0134 N73 14132

A 3d tracing for acoustic gravity waves p0134 N73 14133

Further remarks about traveling ionospheric disturbances attributed to jet stream activity at mid latitude p0136 N73 14147

FM-CW radar studies of production of turbulent instability within thermally stable layers by internal waves p0137 N73 14151

Propagation of submicrosecond HF pulses through travelling ionospheric disturbances p0139 N73 14165

## NATIONAL PHYSICAL LAB., TEDDINGTON (ENGLAND)

Theoretical and experimental investigations of wing body configurations at low supersonic speeds p0002 N71 19358

Fibre reinforced materials p0206 N71 27043

The NPL ultrasonic tank: its uses in polymer and fibre composite testing p0207 N72 12494

Packet Switching network p0158 N72 22171

Experimental methods for composite materials p0209 N72 29593

## NATIONAL RESEARCH COUNCIL OF CANADA, OTTAWA (ONTARIO)

Some factors influencing the choice of a simulator p0171 N71 16066

Experiments with a heuristic on-line picture processing language p0151 N72 11180

Jet fuel specifications p0251 N72 11669

Fuel cleanliness p0252 N72 11676

Wind tunnel testing of V-STOL engine models: Some observed flow interaction and tunnel effects p0284 N72 13693

Flow distortion and performance measurements on a 12 inch fan in wing model for a range of forward speeds and angle of attack settings p0265 N72 16702

Observations of 48 MHz auroral radar propagation on a network in the auroral zone p0127 N72 21127

Technical evaluation report on Production and Energies Panel 37th Meeting on Aircraft Fuels, Lubricants and Fire safety p0255 N72 27811

JAGARD AR 44 Information extension services for industry p0159 N73 24211

Accurate finite element modelling of flat and curved stiffened panels p0293 N73 29911

## NATO MRCA DEVELOPMENT AND PRODUCTION MANAGEMENT AGENCY, MUNICH (WEST GERMANY)

Design problems of military aircraft as affected by turbulence p0059 N74 17335

## NAVAL AEROSPACE MEDICAL INST., PENSACOLA, FLA.

The thousand aviators: A thirty year follow up p0092 N71 22314

Descriptive catalog of aerospace medical biodynamics facilities in the United States and Canada p0095 N71 23342

The US Navy Special Board of Flight Surgeons: Keep them flying safely p0098 N72 14100

## NAVAL AEROSPACE MEDICAL RESEARCH LAB NEW ORLEANS, LA

Human dynamic response to minus Gx impact acceleration p0100 N72 19131

Theoretical mechanics for expressing impact acceleration response of human beings p0100 N72 19132

Non fatal ejection: vertebral fracture and its prevention p0083 N73 23059

Specialized anthropometry requirements for protective equipment evaluation p0084 N73 23066

## NAVAL AEROSPACE MEDICAL RESEARCH LAB PENSACOLA, FLA.

Orientation error accidents in Army aviation aircraft p0071 N72 25034

Theory of development of reactions to whole body motion considered in relation to selection, assignment and training of flight personnel p0072 N72 25044

Magnetic fields and man: Where do we stand today? [NASA CR 127049] p0076 N72 26055

Effects of part whole training procedures upon the acquisition of complex skills to be performed under stress p0106 N73 19153

Assessment of reactions to vestibular disorientation stress for purposes of aircrew selection p0079 N73 21096

Motion sickness questionnaire and field independence scores as predictors of success in Naval aviation training p0079 N73 21097

The thousand aviators: Aging and the blood pressure p0084 N74 13786

Elevated blood pressure in aircrew p0085 N74 13787

Human factors approach to aircraft accident analysis p0107 N74 18799

## NAVAL AIR DEVELOPMENT CENTER, JOHNSTOWN, PA.

Stress corrosion testing of titanium alloys p0287 N72 21932

Disorienting effects of aircraft catapult launches p0071 N72 25037

## NAVAL AIR STATION, NORFOLK, VA.

A report of aviator drowning and aviator salvage in high performance fighter aircraft p0095 N72 14094

Psychophysiological and environmental factors affecting disorientations in naval aircraft accidents p0071 N72 25036

## NAVAL AIR SYSTEMS COMMAND, WASHINGTON, D.C.

Low altitude high speed flight experience p0029 N71 23421

Recent US Navy flying qualities research p0040 N72 32037

Aerodynamic design and flight test of US Navy aircraft at high angles of attack p0043 N73 15020

Flight simulation: a significant aid in aircraft design p0045 N73 17001

Development of techniques to measure in flight drag of a US Navy fighter airplane and correlation of flight measured drag with wind tunnel data p0022 N74 14734

NAVAL AIR TEST CENTER, PATUXENT RIVER, MD

Carrier Suitability Tests p0036 N72 20988

US naval test pilot training p0037 N72 20996

A new look at helicopter: level flight performance p0047 N73 21014

## NAVAL ELECTRONICS LAB. CENTER FOR COMMAND CONTROL AND COMMUNICATIONS, SAN DIEGO, CALIF.

Remote sensing of tropospheric structures using high resolution radar p0123 N72 16101

NAVAL ORDNANCE LAB. WHITE OAK, MD

Aerodynamic interaction phenomena produced by a fin protruding partially immersed in a turbulent boundary layer at Mach 5 p0003 N71 19365

Aircraft store interference p0006 N71 19387

An experimental study of the compressible turbulent boundary layer with an adverse pressure gradient p0179 N72 20299

## NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF.

Nozzle and exhaust testing in transonic flight regime p0263 N72 16688

Engine integration and thrust drag definition p0038 N72 27023

Pollution control of airport engine test facilities p0219 N74 14285

## NAVAL RESEARCH LAB., WASHINGTON, D.C.

Wave height measurements with a nanosecond radar p0122 N72 16094

Remote passive microwave measurements of the sea p0122 N72 16095

Remote sensing of ocean effects with radar p0122 N72 16096

## NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, ANNAPOLIS, MD.

Influence of test method on stress corrosion behavior of aluminum alloys in sea water p0288 N72 21919

Air cobalt base alloys intrinsically more resistant to hot corrosion than alloys based on nickel? p0203 N73 23612

## NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, BETHESDA, MD.

Recent developments in circulation control rotor technology p0051 N73 21050

## NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, WASHINGTON, D.C.

The effect of angle of attack on induced rolling moment for a low aspect ratio missile p0002 N71 19363

A study of captive flight drag and separation characteristics of lifting body, half bomb and half pod store configurations p0076 N71 19386

Prediction of store launch characteristics through statistical methods p0096 N71 19388

## NAVAL SUBMARINE MEDICAL CENTER, GROTON, CONN.

Vertigo in divers p0072 N72 25043

## NAVAL WEAPONS LAB., DAHLGREN, VA.

Aerodynamic drag and lift of general body shapes at subsonic, transonic and supersonic Mach numbers p0019 N74 14712

Retrieval of microfiche: Random access p0160 N74 16934

## NEW YORK UNIV., N.Y.

Engine airplane interference and wall corrections in transonic wind tunnel tests p0014 N72 11877

Review of the conclusions of the AGARD ad hoc committee on engine airplane interference and wall corrections in transonic wind tunnel tests p0263 N72 16686

Engine airplane interference: definition of the problem and related basic fluid dynamic phenomena p0037 N72 27017

Reduction of NO formations by premixing p0212 N74 14272

Nonlinear time dependent problems in fluid dynamics p0185 N74 22916

## NEWCASTLE UPON TYNE UNIV. (ENGLAND)

Stress corrosion test methods: The European Federation of Corrosion contribution p0285 N72 21904

## NIELSEN ENGINEERING AND RESEARCH, INC. PALO ALTO, CALIF.

A calculator method for predicting store separation trajectories at speeds up to the critical speed p0005 N71 19319

## NORDEK TEKNIKE HOEGSKOLE, TRONDHEIM

Transfer equivalent p0165 N74 13914

## NORTH AMERICAN ROCKWELL CORP. ANAHEIM, CALIF.

Overview of aerospace vehicle computer applications p0155 N72 21212

The likelihood of looking at a target p0302 N73 19960

## NORTH AMERICAN ROCKWELL CORP. DOWNEY, CALIF.

Real time programs for aerospace vehicles p0155 N72 21215

Space station information system requirements: A case history of man-machine system definition p0279 N73 23887

## NORTH AMERICAN ROCKWELL CORP. LOS ANGELES, CALIF.

Flying qualities interaction with elastic airframes p0039 N72 32031

## NORTH AMERICAN ROCKWELL CORP., THOUSAND OAKS, CALIF.

Semi adaptive approach to pattern recognition p0153 N72 11199

An ultra high vacuum system for determining the effects of gaseous environments on fatigue and fracture properties of metals p0287 N72 21916

## NORTH ATLANTIC TREATY ORGANIZATION, BRUSSELS (BELGIUM)

Propagation criteria with tactical satellite communications p0132 N73 10201

System considerations in tactical satellite communications p0132 N73 10202

## NORTHEASTERN UNIV., BOSTON, MASS.

An approach to the analysis of coupling between acoustic gravity waves and electromagnetic waves p0136 N73 14162

## NORTHROP CORP., HAWTHORNE, CALIF.

Recent experience in the transonic testing of two dimensional swept and straight wings with high lift devices p0012 N72 11860

Situation and analysis in establishing flying qualities criteria p0039 N72 32026

Parametric studies of separating turbulent boundary layer flows p0041 N73 15003

## NORTHROP CORP. PALOS VERDES PENINSULA, CALIF.

Automatic acquisition and tracking methods employed in the joint services in-flight data transmission system (JIFDATS) p0278 N73 23885

## NORTHWESTERN UNIV., EVANSTON, ILL.

Characterization, selection and use of high strength steels p0205 N71 27040

## NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT, KJELLER

High latitude satellite navigation system design considerations for midcourse guidance p0231 N73 20711

The influence of pre-collision and multiple fading on frequencies between 10 and 18 GHz p0142 N73 26134

## NORWEGIAN INST. FOR AIR RESEARCH, KJELLER

A systematic approach to the study of the connection between emission and ambient air concentrations p0220 N74 14295

## NOTTINGHAM UNIV. (ENGLAND)

Calculation and simulation of the effects of two complex search situations p0302 N73 19963

Peripheral acuity with complex stimuli at two viewing distances p0303 N73 19965

O

## OFFICE FOR SCIENTIFIC AND TECHNICAL INFORMATION, LONDON (ENGLAND)

The role of OSTI in information research and development p0160 N74 16923

## OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES, PARIS (FRANCE)

Heat flux measurements on heated turbine blades p0257 N71 17378

Thermochemical properties of refractory compounds for aircraft gas turbines p0259 N71 17391

Coating of turbine blades by liquid crystals p0260 N71 17398

Calculations of aerodynamic interactions between lifting elements of an airplane in supersonic transonic and subsonic flow p0002 N71 19362

Wind tunnel investigation into aerodynamic interactions induced by drop tanks p0005 N71 19376

Aerodynamics of variable sweep p0075 N71 26054

A new technique for aerodynamic testing: edge studies p0027 N71 26064

Transfer functions of flexible aircraft in atmospheric turbulence p0007 N71 23213

Representation of a wing in the lifting line application of the interaction calculations of two wings in tandem p0008 N71 23336

Measurements of aerodynamic characteristics of swept-back wings in supersonic flow p0009 N71 29347

Application of the lifting surface theory to wings provided with control surfaces p0009 N71 29347

Thermal stability of a turbulent propellant jet: heat transfer analysis p0254 N72 11699

Transient testing of the engine inlet and intake and afterburner p0011 N72 11696

Wind tunnel qualification by conformal airspeed and lift flight verification p0014 N72 11877

Methods of static data measurements in supersonic flow p0017 N72 11495

Study of interaction between a turbulent shear layer and a turbulent jet p0228 N72 15407

Image analysis by multiple lighting p0225 N72 16114

## P

Problems of measurement on model of the thrust of a supersonic aircraft after body standard nozzles

p0263 N72 16689

Velocity distribution at a supersonic compressor inlet

p0267 N72 16713

Starting conditions of a mixed compression asymmetric hypersonic inlet

p0267 N72 16715

Theoretical and experimental study of the coexistence of two types of flow in a channel with constant cross section

p0267 N72 16716

Automatic tracking of Q switched laser rangefinders

p0194 N72 19513

Application of an improved mixing length model to the study of three dimensional boundary layers

p0177 N72 20284

Injection of a turbulent boundary layer wall with a strange gas

p0180 N72 20303

Computation of unsteady aerodynamic forces on helicopter rotor blades

p0017 N73 14003

Airfoil stall prediction in incompressible flow

p0041 N73 15002

Influence of angle of attack and deflection on boundary layer flow in upright cascade blades

p0269 N73 19603

Method of calculating three dimensional turbulent boundary layer separation with application to a simple turbomachine case

p0270 N73 19808

Results of interaction of shock wave with turbulent boundary layers at moderate Mach supersonic numbers

p0271 N73 19815

Behavior of boundary layer in supersonic straight and angular blade cascades: fixed and mobile

p0271 N73 19817

Aerodynamic forces computation and measurement on an oscillating aerodynamic profile with and without stall

p0050 N73 21342

Aeroelasticity of rotary wing aircraft p017 N73 22952

A French collision avoidance systems of time frequency type

p0235 N73 23713

General guidance for the design of manned aerospace vehicles

p0278 N73 23883

Fabrication of refractory composite materials by directional solidification

p0272 N73 27492

Theoretical study of the residual evolution of polluting products in turbojet exhausts

p0220 N74 14294

Modelization of turbomachine combustors for pollution studies

p0220 N74 14298

Drag and separation

p0020 N74 14722

The motor driven tunnel

p0174 N74 16991

A new approach to gust alleviation of a flexible aircraft using an open loop device

p0050 N74 17345

## OFFICE OF NAVAL RESEARCH, ARLINGTON, VA

Acoustic fatigue of humans exposed to noise

p0067 N71 20352

## OFFICE OF TELECOMMUNICATIONS BOULDER, COLO

Estimating attenuation, scattering, and scattering due to rain for satellite ground systems

p0147 N74 13856

## OFFICE OF THE AIR FORCE SURGEON GENERAL, WASHINGTON, D.C.

Human exposure criteria to laser energy

p0084 N73 23067

## OFFICE OF THE SECRETARY OF DEFENSE (RESEARCH AND ENGINEERING), WASHINGTON, D.C.

Integrity of ICNI systems

p0236 N73 23721

## OFFICE OF THE SURGEON GENERAL (AIR FORCE), WASHINGTON, D.C.

Causes for medical grounding of pilots and navigators in the United States Air Force 1959-1969

p0396 N72 14096

Suspensions of pilots and navigators from flying status for medical reasons in the United States Air Force 1969-1969

p0397 N72 14105

## UFFICINE GALILEO S.P.A., FLORENCE (ITALY)

Sensors of the earth infrared radiation and solar sensors for satellite attitude determination

p0192 N72 19496

Scanning radiometers for meteorological satellite

p0192 N72 19497

Strapped down line of sight guidance system study

p0277 N73 20685

## OHIO STATE UNIV., COLUMBUS

Acoustic emissions and slow crack growth in high strength steel

p0287 N72 21917

Ethyl alcohol and performance: Military pilots in flight studies

p0081 N73 21113

Vaporization losses from CO2 phase two states

p0292 N73 23607

Computational and analytical determination of RCS

p0144 N74 11356

Practical problems in statistical hydrography - 2

p0108 N74 20735

## OREGON STATE UNIV., CORVALLIS

Variation of optical sea parameters with depth

p0241 N73 33526

## ORLEANS UNIV. (FRANCE)

Relations between chemical composition and test stage of the reaction and formation of oxide layers

p0291 N73 23503

## OSLO UNIV. (NORWAY)

Effect of suspension transport on the particle size studied in a two dimensional high pressure jet

p0218 N74 14728

## PRINCETON UNIV., N.J.

Ignition of fuels by a hot projectile

p0252 N72 11683

Helicopter IFR flight path control system

p0033 N72 11933

The analysis of steady state and random flight data

p0195 N73 10455

The prediction of axial compressor performance with emphasis on the effect of annulus wall boundary layers

p0270 N73 19812

## PURDUE UNIV., LAFAYETTE, IND.

Automatic medical diagnosis using nonparametric sequential classification procedures

p0152 N72 11184

## Q

## QUEEN MARY COLL. (LONDON) (ENGLAND)

An experimental investigation of the turbulent boundary layer along a streamwise corner

p0180 N72 20302

Role of fluid dynamics in aircraft stall and gusts

p0041 N73 14999

Microplasticity: materials for inertial navigation systems

p0228 N73 20697

QUEENS UNIV., BELFAST (NORTHERN IRELAND)

Effects of turbulence on flow visualization methods

p0199 N72 25497

QUEENSLAND UNIV., BRISBANE (AUSTRALIA)

Atmospheric pressure waves at Brisbane and their association with certain atmospheric and solar events

p0136 N73 14145

## R

## RADIO AND SPACE RESEARCH STATION, SLOUGH (ENGLAND)

Effects of tropospheric layer structure on propagation and signal distortion

p0115 N71 21423

Transhorizon propagation studies at VHF and UHF

p0116 N71 21426

Polarization effects on sky wave paths at high latitudes

p0129 N72 21145

The influence of rain on the line of sight propagation at 110 GHz in SE England

p0142 N73 26135

Scatter path attenuation at frequencies above 10 GHz

p0142 N73 26140

Introductory survey to session 1: Propagation over irregular terrain

p0145 N74 13847

Statistics of high level beyond horizon signals at 2.2 GHz and 2.6 GHz and measurements of the variation of the arrival angle structure

p0146 N74 13860

RADIO CORP. OF AMERICA, MOORESTOWN, N.J.

Correlation between estimator models and system operating data

p0189 N71 36778

Cost effective use of built in test provisions

p0189 N71 36780

Relationships between program test and user support costs

p0193 N71 36784

Reliability and computer aided design

p0165 N74 13910

RADIO CORP. OF AMERICA, VAN NUYS, CALIF.

SECANT: A solution to the problem of mutual coupling

p0235 N73 23712

RANDOMLINE INC., WILLOW GROVE, PA.

Contact and neural effects of radar wavelengths

p0069 N71 20354

RAYTHEON CO., BEDFORD, MASS.

Pulse doppler missile guidance: Representational variables and associated fire control considerations

p0227 N72 21693

RAYTHEON CO., SUDBURY, MASS.

Phase coherent HF radar observations of barium measured in the Arctic atmosphere

p0128 N72 21136

RCA SERVICE CO. INC., PATRICK AFB, FLA.

Underwater lenses and optical depth

p0247 N73 33635

REDAC SOFTWARE LTD., TEWKESBURY, ENGLAND

Computer aided design of multilayer printed circuit boards

p0169 N74 13934

RENSELAER POLYTECHNIC INST., TROY, N.Y.

Stress analysis for elevated temperature flow cycle fatigue with hold time

p0261 N71 17403

Processing and display of time varying signal information with application to radar detection of tactical signals

p0154 N72 17209

Filter and matrix materials for advanced computers

p0209 N72 29591

A nonlinear digital filter with emphasis on digital communications and filtering

p0131 N73 10192

A rigorous evaluation of test methods for sensors

p0132 N73 10200

Some fundamental properties of communication systems

p0143 N73 10504

RESEARCH INST. OF NATIONAL DEFENCE, STOCKHOLM (SWEDEN)

Brillouin frequency propagation in plasma at 17.5 and 100.0 MHz

p0115 N71 21429

Variation of the Brillouin frequency with plasma density and temperature between 180 MHz and 10 GHz in air plasma

p0145 N74 13853

The Brillouin frequency of very high frequency plasma at 17.5 and 100.0 MHz

p0147 N74 13861

# CORPORATE SOURCE INDEX

**REYNOLDS METALS CO., RICHMOND, VA**  
Progress toward standardization of SCC test techniques by the American Society for Testing and Materials  
p0285 N72 21902

**RHODE ISLAND UNIV., KINGSTON**  
A simple analysis of two dimensional turbulent skin friction with arbitrary wall and freestream conditions  
p0176 N72 20279

**ROCHESTER UNIV., N.Y.**  
Body armics of sports injuries  
p0099 N72 19128

**ROCKWELL INTERNATIONAL CORP., ANAHEIM, CALIF.**  
Computer aided design analysis of modern large scale circuits and subsystems  
p0167 N74 13928

**ROHR CORP., CHULA VISTA, CALIF.**  
Sonic fatigue of diffusion bonded titanium sandwich structure  
p0293 N73 29919

**ROLLS-ROYCE LTD., BRISTOL (ENGLAND)**  
Olympus 593 turbine cooling  
p0257 N71 17376

Left augmentation devices and their effect on the engine  
Part 1. Interface problems between engine and airframe  
p0026 N71 20061

Left augmentation devices and their effect on the engine  
Part 2. Thermodynamic problems and some possible solutions  
p0026 N71 20062

Lubricant experience and duties in a civil superion gas turbine engine  
p0254 N72 11697

The role of boundary layers in axial flow turbomachines and the prediction of their effects  
p0269 N73 19806

Potential use of composite materials for gas turbine static structures  
p0213 N73 27495

**ROLLS-ROYCE LTD., DERBY (ENGLAND)**  
Nozzle guide vane cooling. The state of the art  
p0260 N71 17396

Thermal fatigue. Nim.  
p0260 N71 17400

Rapid mixing nozzles for V-STOL applications  
p0285 N72 16699

**ROLLS-ROYCE LTD., WATFORD (ENGLAND)**  
Industrial and technological problems of small gas turbines for helicopters and ground transport  
p0262 N71 26956

The influence of fretting on fatigue. Part 3  
[AGARD R 45]  
p0290 N72 28902

**ROME AIR DEVELOPMENT CENTER, GRIFFISS AFB, N.Y.**  
Automatic speaker recognition systems  
p0151 N72 11179

On the design of waveform classification systems by interactive man-machine methods  
p0154 N72 11202

High altitude signal transmission characteristics  
p0129 N72 21144

Microforms. Present economics and future use  
p0159 N73 24206

**ROME UNIV. (ITALY)**  
Propagation effects of a variable scatter mechanism  
p0117 N71 23452

**ROYAL AERONAUTICAL SOCIETY, LONDON (ENGLAND)**  
Ground handling techniques and systems  
p0195 N73 10453

**ROYAL AIR FORCE CENTRAL MEDICAL ESTABLISHMENT, LONDON (ENGLAND)**  
Current nasal and aural indications for grounding  
p0097 N72 14106

The disorientation accident. Philosophy of instrument flying training  
p0073 N72 25046

Hearing conservation in aircrew and ground support personnel  
p0077 N73 17101

AVMED policy on sleep in aircrew  
p0080 N73 21108

Residue of behaviour therapy in flying phobias  
p0088 N74 18782

Depression in aircrew  
p0088 N74 18784

**ROYAL AIR FORCE HOSPITAL, ELY (ENGLAND)**  
Medication and drugs in aircrew  
p0080 N73 21105

Ocular side effects of drugs in aviation medicine  
p0082 N73 21121

**ROYAL AIR FORCE HOSPITAL WEGBERG (WEST GERMANY)**  
Problems in the clinical assessment of raised arterial blood pressure in aircrew  
p0074 N72 25054

**ROYAL AIR FORCE INST. OF AVIATION MEDICINE, FARNBOROUGH (ENGLAND)**  
Effect of posture on tolerance to positive Gz acceleration  
p0068 N71 20357

The novel task as a measure of performance under environmental stress  
p0069 N71 20363

A linear deceleration track  
p0103 N72 19151

A case for the negative g strap  
p0104 N72 19158

Protection of the head  
p0104 N72 19160

Spatial disorientation and the break off phenomena  
p0072 N72 25042

Laser safety. Some considerations in the design of a code of practice  
p0076 N72 26057

Colour vision requirements in different operational roles  
p0077 N73 19572

Emotional and cardiovascular aspects of centrifuge effect of beta receptor blockade on heart rate response  
p0105 N73 19149

Use of hypnosis by aircrew. 1. Operational considerations and experimental studies  
p0080 N73 21106

Use of hypnosis by aircrew. Adaptive tracking as a technique for the evaluation of performance decrements related to the flying task  
p0080 N73 21109

Use of hypnosis by aircrew. Considerations of metabolism and excretion  
p0081 N73 21118

Hybrid computing. A technique for the immediate analysis of physiological data  
p0083 N73 23064

Human factors problems in conflict detection and resolution  
p0235 N73 23714

The application of aircrew opinions on cockpit tasks and equipment to flight safety research  
p0107 N74 18807

The psychological role in aircraft accident investigation  
p0107 N74 18803

Use of nystagmography in the study of aircrew with spatial disorientation  
p0108 N74 20736

A model for the prediction of the nystagmic response to angular and linear acceleration stimuli  
p0110 N74 20752

**ROYAL AIR FORCE INST. OF PATHOLOGY AND TROPICAL MEDICINE, AYLESBURY (ENGLAND)**  
Histopathological responses to deceleration  
p0099 N72 19124

**ROYAL AIR FORCE, FARNBOROUGH (ENGLAND)**  
Psychiatric casualties among aircrew of the Royal Air Force of Great Britain for ten years 1959 to 1968  
p0098 N72 14110

Technical evaluation of the Aerospace Medical Panel Specialists Meeting on Linear Acceleration Impact Types  
p0098 N72 14110

Training pilots to assess flight systems at the Empire Test Pilots School  
p0036 N72 20995

A review of United Kingdom (RAF and Army) statistics on spatial disorientation in flight: 1960-1970  
p0071 N72 25033

Improve methods of clinical electrodiagnosis in prognosis of lower motor neuron lesions  
p0074 N72 25058

Assessment of behaviour therapy in the treatment of flying phobias  
p0088 N74 18783

**ROYAL AIR FORCE, HIGH WYCOMBE (ENGLAND)**  
Operational considerations and systems reliability  
p0190 N71 36788

**ROYAL AIR FORCE, MARLOW (ENGLAND)**  
Automatic message switching and data traffic handling in a military communications net  
p0133 N73 10206

**ROYAL AIRCRAFT ESTABLISHMENT, BEDFORD (ENGLAND)**  
Motion visual and aural cues in pilot's flight simulation  
p0171 N71 16064

Some aspects of viscous-inviscid interactions at transonic speeds and their dependence on Reynolds number  
p0011 N72 11856

Some applications of boundary layer control by blowing to airfoils for V-STOL aircraft  
p0214 N72 16697

Some boundary layer measurements on a flat plate at Mach numbers from 2.5 to 4.5  
p0117 N72 20288

Stability and control tests on a slender wing research aircraft  
p0016 N72 20990

Turbulence models for the assessment of handling qualities during take off and landing  
p0019 N71 32030

The dynamic analysis of buffeting and related phenomena  
p0043 N73 15018

The role of theory and calculations in the refinement of flying qualities  
p0044 N73 16999

The role of free flight models in aircraft research and development  
p0045 N73 17002

The operation of helicopters from small ships  
p0046 N73 21010

Some flight experiments on the XH 51 A helicopter  
p0047 N73 21015

PAE experience in the use of a plotted ground based simulator for helicopter handling studies  
p0049 N73 21030

The influence of the future landing guidance system on integration of short take off and landing and conventional air traffic at a major airport  
p0213 N73 23703

Manual handling in fog  
p0210 N73 23898

Some considerations of tests under dynamic conditions in low speed wind tunnels  
p0173 N73 26284

The need for high Reynolds number transonic tunnels  
p0183 N73 26282

On the science of free stream turbulence on a turbulent boundary layer as it relates to wind tunnel testing at subsonic speeds  
p0184 N73 26283

Measurements of the drag of some characteristic aircraft excrescences immersed in turbulent boundary layers  
p0019 N74 14714

The drag of externally carried stores. Its prediction and alleviation  
p0021 N74 14729

The development of an efficient and economical system for the generation of quasi-transonic flows suitable for model testing at high Reynolds number  
p0174 N74 16990

Application of energy management concepts to flight path control in turbulence  
p0090 N74 17744

Some comments on methods of avoiding the effects of turbulence  
p0060 N74 17746

**ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH (ENGLAND)**  
Some remarks on the interference between a swept wing and a fuselage  
p0001 N71 19354

Flight investigation of a technique for the measurement of the total and interference drag of external stores  
p0006 N71 19384

Some comments on characteristics of high lift wings  
p0027 N71 20055

Human pilot modelling  
p0027 N71 20055

Calculation methods for unsteady aerodynamic forces of tandem surfaces and T-tails in subsonic flow  
p0007 N71 29335

A supersonic box calculation method for the calculation of unsteady aerodynamic forces of tandem surfaces  
p0008 N71 29337

Applications of unsteady airforce calculation methods to AGARD interference configurations  
p0009 N71 29342

Fire and explosion protection of fuel tank ullage  
p0253 N72 11690

Simulated crash tests as a means of raising aircraft safety  
p0254 N72 11692

Scale effects in flows over swept wings  
p0011 N72 11855

A type of stall with leading edge transonic flow and rear separation  
p0011 N72 11858

Some factors relevant to the simulation of full scale flows in model tests and to the specification of new high Reynolds number transonic tunnels  
p0015 N72 11883

A scheme for a quiet transonic flow suitable for model testing at high Reynolds number  
p0016 N72 11867

The implications of operating helicopters in poor visibility  
p0031 N72 11919

The effects of semirigid rotors of helicopter autorotative design  
p0032 N72 11928

Active stabilization  
p0277 N72 12866

Blast testing aircrew escape equipment including an account of a new transonic test facility  
p0102 N72 19147

Hybrid microcircuit technology in the British national space program  
p0191 N72 19465

An experimental Canopus star sensor  
p0192 N72 19499

Data storage for small scientific spacecraft  
p0193 N72 19502

A modular spacecraft PCM data conditioning system  
p0193 N72 19501

Some aspects of multipath fading in aeronautical satellite systems  
p0194 N72 19509

Measurement of antenna radiation patterns on spacecraft  
p0194 N72 19512

Chirp modulation system in aeronautical satellites  
p0194 N72 19514

Numerical analysis and simulation evolution  
p0226 N72 27687

Methodology of research into command line of sight and homing guidance  
p0227 N72 27692

Technical evaluation report on 23d Avionics Panel Technical Meeting on Aerospace Telecommunications Systems 15-18 May 1972  
p0131 N73 10188

The low speed stalling of wings with high lift devices  
p0042 N73 15008

The effect of leading edge geometry on high speed stalling  
p0042 N73 15010

Some effects of change in spectrum severity and spectrum shape on fatigue behaviour under random loading  
p0291 N73 16898

Pilot workload. A conceptual model  
p0045 N73 17010

The role of theoretical studies of flight dynamics in relation to flight testing  
p0045 N73 17011

Electrical generation and distribution systems for future supersonic aircraft  
p0066 N73 19054

Early thoughts on compound strains  
p0104 N73 19144

A flight test programme to study the effects of environmental stresses on a crew operating military strike aircraft  
p0105 N73 19145

Fault detection possibilities in a system employing Kalman filtering  
p0231 N73 20712

Datum positions and velocities for the evaluation of mental navigation systems  
p0232 N73 20716

The derivation and verification of a new rotor profile on the basis of flow phenomena. Aeroflow research and flight tests  
p0051 N73 21047

A forward area homing and landing guidance concept for military aircraft  
p0234 N73 23709

The experimental evaluation of automated navigation systems  
p0280 N73 23896

Airfield performance prediction methods for transport and combat aircraft  
p0053 N73 24044

Review of two methods of optimizing aircraft design  
p0054 N73 24054

Library and information services at the Royal Aircraft Establishment. Some problems and their present solutions  
p0158 N73 24204

Acoustic considerations for noise experiments at moderate scale in subsonic wind tunnels  
p0173 N73 26247

Some examples of the application of methods for the prediction of boundary layer transition on sheared wings  
p0183 N73 26287

Instability of laminated composite plates  
p0212 N73 27489

Some considerations of the fatigue behaviour of aluminium alloy structures under aerodynamic loading  
p0294 N73 29921

Aircraft inertial system testing and evaluation in the United Kingdom  
p0227 N74 14352

Aircraft drag prediction for project appraisal and performance estimation  
p0019 N74 14716

The optimisation of statically indeterminate structures by means of approximate geometric programming  
p0226 N74 14660

Some considerations of future low speed tunnels for Europe  
p0173 N74 16988

Influence of pilot and aircraft characteristics on structural loads in operational flight  
p0059 N74 17728

[AGARD R 608]  
The design of automatic flight control systems to reduce the effects of atmospheric disturbances  
p0060 N74 17743



The role of the major fatigue test in the acceptance certification and safe utilization of strike aircraft  
p0011 N74 19658

The metallurgical aspects of fatigue and fracture toughness  
p0204 N74 23109

**ROYAL ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT, FORT HALSTEAD (ENGLAND)**  
An assessment of the accuracy of transonic drag measurement in a large modern wind tunnel  
p0022 N74 14736

**ROYAL AUSTRALIAN NAVY SCHOOL OF UNDERWATER MEDICINE, BALMORAL**  
Vertigo in diving  
p0110 N74 20753

**ROYAL NAVAL AIR MEDICAL SCHOOL, HILLHEAD (ENGLAND)**  
Clinical causes for grounding. A review of Royal Naval experience 1962-1970  
p0095 N72 14092

**ROYAL NETHERLANDS AIR FORCE, THE HAGUE**  
Influence of social-relational factors on operational flying capacity. A system-oriented approach  
p0089 N74 18751

**ROYAL NETHERLANDS AIRCRAFT FACTORIES FOKKER, AMSTERDAM**  
Aerodynamics of wing stall of the Fokker F28  
p0043 N73 15015

Rationalization of design loads in relation to present and proposed airworthiness requirements  
p0059 N74 17740

**ROYAL NETHERLANDS AIRCRAFT FACTORIES FOKKER, STIPHOLDOOT**  
Adjustment of flying qualities by wind tunnel testing  
p0045 N73 17000

Design and manufacturing aspects of composite materials with organic matrices for application at high temperatures  
p0212 N73 27489

**ROYAL RADAR ESTABLISHMENT, MALVERN (ENGLAND)**  
Nonspecular nonspherical clutter in the VHF and UHF bands  
p0123 N72 21134

Radar Echoing areas of flying animals  
p0144 N74 11961

Radar sea clutter  
p0145 N74 11962

**RUBBER AND PLASTIC RESEARCH ASSOCIATION OF GREAT BRITAIN, SHREWSBURY (ENGLAND)**  
A new test for the glass to resin bond life in GFR  
p0028 N72 12505

**Ruhr UNIV., BOCHUM (WEST GERMANY)**  
The influence of wave drag on hypersonic entropy wake observations  
p0022 N74 14733

S

**SAAB AIRCRAFT CO., LINKÖPING (SWEDEN)**  
Some development trends in the integration of electronic systems in the Swedish aircraft 37 VIGGÉN  
p0079 N73 23889

**SAARLAND UNIV., SANKRUCKEN (WEST GERMANY)**  
Propagation of an electromagnetic pulse in a duct between ground and atmospheric layer  
p0116 N71 21425

Method of calculating propagation of electromagnetic waves in an inhomogeneous atmosphere above rough ground  
p0117 N71 21432

Depolarization of dipole radiation in a medium with a statistically homogeneous and isotropic distribution of electric constant  
p0119 N71 23460

Effect of vegetation upon antenna pattern with scatter propagation on UHF  
p0119 N71 23461

**SACLANT ASW RESEARCH CENTER, LA SPEZIA (ITALY)**  
Establishing small information centres in industry  
p0118 N73 24203

**SAN JOSE STATE COLL., CALIF.**  
Disorientation incidents report by military pilots across 14 years of flight  
p0071 N72 25032

**SANDIA LABS., ALBUQUERQUE, N. MEX.**  
High intensity direct reading heat flux gauge  
p0190 N71 38789

**SASKATCHEWAN UNIV., SASKATOON**  
Polarization of waves scattered from aurora  
p0127 N72 21133

**SCHOOL OF AEROSPACE MEDICINE, BROOKS AFB, TEX.**  
Effect of acute and chronic exposure to 21 mm Hg ambient F<sub>sub</sub> CO<sub>2</sub> on exercise response of normal man  
p0070 N71 20370

The effects of aging on body composition and exercise performance in the USAF aircrew population  
p0093 N71 27316

A comparison of the effects of early cardiovascular disease and aging upon maximal exercise performance in the USAF aircrew population  
p0093 N71 27317

USAF aeromedical consult service experience in causes for grounding over the past fifteen years  
p0066 N72 24065

Changing concepts in medical reasons for grounding in the USAF aeromedical consult service  
p0096 N72 24101

Extended electrocardiographic monitoring with emphasis on computer analysis of the records  
p0074 N72 25053

History, rationale and verification of color vision standards and testing in the United States Air Force  
p0077 N73 19089

Estimates of physiologic reserve after acceleration exposure in man  
p0105 N73 19150

Findings on the cost of flying transport missions  
p0106 N73 19151

The use of physiological protective maneuvers in high acceleration environments  
p0106 N73 19156

The USAF SAM selection test and rehabilitation program of motion sick pilots  
p0079 N73 21098

Drug abuse detection efforts  
p0081 N73 21117

Aeromedical evaluation of the phased flight concept for oxygen breathing systems  
p0083 N73 23065

Returning women with abnormal exercise tests and normal coronary angiograms to flying status  
p0085 N74 13788

Myocardial and cerebral function during exposure to carbon monoxide  
p0085 N74 13789

Management of glaucoma in an ageing flying population  
p0086 N74 13799

The occurrence of hyperlipidemia in flying and nonflying subjects of the USAF SAM card ovascular disease study  
p0087 N74 13803

The reparability of an abnormal 2-hour glucose tolerance test  
p0087 N74 13805

Characteristics of life stress in a population of military aviators  
p0088 N74 18787

Aeromedical research and clinical applications of averaging techniques in psychophysiology  
p0110 N74 20750

**SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIF.**  
HF measurements of ocean wave directional spectra  
p0148 N74 13867

**SCRIPPS INSTITUTION OF OCEANOGRAPHY, SAN DIEGO, CALIF.**  
Air to ground visibility of light in low background levels  
p0303 N73 19967

**SELENIA S.P.A. ROME (ITALY)**  
One-axis R.F. attitude sensor of a geostationary satellite  
p0111 N72 15492

A general purpose computer for spacecraft applications  
p0280 N73 23894

**SERVICE DE SANTE DES ARMEES, TOULON (FRANCE)**  
Biological effects of UHF electromagnetic radiation  
p0076 N72 26053

**SERVICE TECHNIQUE DE L'AERONAUTIQUE, PARIS (FRANCE)**  
Aeronautical significance of polycyclic saturated hydrocarbons  
p0251 N72 11670

Flight safety with a remote control: requirements and implementation  
p0031 N72 11918

Comparison of French and United States flying qualities requirements  
p0038 N72 32018

Tactical flight of helicopters and repercussions on the conception  
p0046 N73 21009

Reliability and safety of operating mechanical helicopter pedals  
p0047 N73 21012

The estimation of aerodynamic coefficients necessary for performance calculations  
p0053 N72 24046

Aircraft mass  
p0053 N72 24047

**SERVICE TECHNIQUE DE LA NAVIGATION AERIENNE, PARIS (FRANCE)**  
TAM TAM system  
p0234 N73 23710

**SERVICE TECHNIQUE DES TELECOMMUNICATIONS DE L'AIR, PARIS (FRANCE)**  
Utilization and suppleness of high numerical discharge support in telecommunications  
p0131 N73 10194

**SERVICO DE TELECOMUNICACOES MILITARES, LISBON (PORTUGAL)**  
Analysis of 11 GHz band propagation in Portugal  
p0148 N74 13869

**SERVIZIO METEOROLOGICO ITALIANO MILANO**  
Computer optimization of microwave integrated circuits design  
p0166 N74 13920

**SHAPE AIR DEFENSE TECHNICAL CENTER, THE HAGUE (NETHERLANDS)**  
Ground terminal measurement requirements with respect to satellite communications link availability  
p0133 N73 10203

**SHELL DEVELOPMENT CO., EMERYVILLE, CALIF.**  
Cooling of advanced engines by endothermic reactions of hydrogen fuels  
p0251 N72 11672

**SHELL RESEARCH, LTD., CHESTER (ENGLAND)**  
Fuels for supersonic and hypersonic aircraft  
p0251 N72 11671

Electrostatic charging in the handling of aviation fuels  
p0253 N72 11686

**SIAT MARCHETTI S.P.A., VARESE (ITALY)**  
Aerodynamic effects of helicopter components in other than rotorcraft  
p0051 N73 21052

**SIEMENS A.G. MUNICH (WEST GERMANY)**  
Holographic pattern recognition using a microcharge correlator  
p0153 N72 11194

Differences and compatibilities in helicopter and fixed wing Doppler sensor technology  
p0031 N72 11923

The adaptive regulation of transmission systems  
p0132 N73 10199

State of art and future trends of computer aided design of microwave integrated circuits  
p0166 N74 13918

**SIEMENS SCHUCKERTWERKE A.G. MUNICH (WEST GERMANY)**  
Testing the reliability of avionics equipment for use in applications  
p0190 N73 36782

**SIGMA ASSOCIATION, HAMBURG (WEST GERMANY)**  
Ducting properties of elevated layers  
p0147 N74 13862

**SIGNALS RESEARCH AND DEVELOPMENT ESTABLISHMENT, CHRIS. CHURCH (ENGLAND)**  
Introduction to spread spectrum techniques  
p0143 N73 32056

**SIGNATRON, INC., LEXINGTON, MASS.**  
Signal distortion and intermodulation with tropospheric scatter  
p0119 N71 23463

**SINGER CO., LITTLE FALLS, N.J.**  
Fault isolation and maintenance concepts of an advanced inertial navigation system  
p0231 N73 20713

**SINGER KEARFOTT, FAIRFIELD, N.J.**  
Area navigation. Cost versus operational benefits  
p0235 N73 23697

**SINGER KEARFOTT, LITTLE FALLS, N.J.**  
Space technology applications to guidance and control displays  
p0225 N72 22641

**SINGER KEARFOTT, PLEASANTVILLE, N.Y.**  
Operational considerations and applications of the Talant 4 landing aid to helicopters  
p0032 N72 11925

**SINGER LIBRARY, GLENDALE, CALIF.**  
Programming characteristics of future G and C computers  
p0156 N72 21216

**SMITHS INDUSTRIES LTD., BISHOPS CLEEVE (ENGLAND)**  
The impact of advancing technology on the evolution of electronic head-up display systems  
p0225 N72 22635

**SMITHS INDUSTRIES LTD., CHELTENHAM (ENGLAND)**  
The experimental probability distribution and its use in assessing the performance statistics of Amosac systems  
p0281 N73 23933

**SMITHS INDUSTRIES LTD., LONDON (ENGLAND)**  
The operational proving of automatic flight control systems in the approach and landing phase  
p0028 N71 23414

**SNELL MEMORIAL FOUNDATION, SACRAMENTO, CALIF.**  
Evaluation and testing of protective headgear  
p0104 N72 19163

**SOCIETA ITALIANA PER L'ESERCIZIO TELEFONICO, ROME (ITALY)**  
The radiation patterns of antennas used in terrestrial microwave line of sight systems  
p0147 N74 13859

**SOCIETA ITALIANA TELECOMUNICAZIONI SIEMENS S.P.A., MILAN (ITALY)**  
Computer design of equalization equalizers  
p0167 N74 13924

**SOCIETE D'APPLICATIONS DES MACHINES MOTRICES S.A. ISSY LES MOULINEAUX (FRANCE)**  
Adiabatic compression of a gas easily measured from pump and motor yield  
p0066 N73 19055

**SOCIETE D'APPLICATIONS GENERALES D'ELECTRICITE ET DE MECANIQUE, PARIS (FRANCE)**  
Method of measuring the inertial qualities of a quasi-spherical rotor  
p0229 N73 20691

**SOCIETE D'ETUDES DES SYSTEMES D'AUTOMATION, PARIS (FRANCE)**  
IMAG 2. Electronic circuit simulations  
p0167 N74 13927

**SOCIETE EUROPEENNE D'ETUDES ET D'ESSAIS D'ENVIRONNEMENT, BUC (FRANCE)**  
Motorist point of view on the effects of low burning rates on pollution  
p0221 N74 14303

**SOCIETE EUROPEENNE DE SEMICONDUCTEURS ET DE MICROELECTRONIQUE, PARIS (FRANCE)**  
SIGMA. An integrated system of computer aided complex circuit designs  
p0168 N74 13932

**SOCIETE FRANCAISE D'EQUIPEMENTS POUR LA NAVIGATION AERIENNE, NEUILLY SUR SEINE (FRANCE)**  
Stability Augmentation Systems (SAS)  
p0033 N72 11932

**SOCIETE GRENOBLOISE D'ETUDE ET D'APPLICATIONS HYDRAULIQUES (FRANCE)**  
PETULA. Program for Turbulent or Laminar flows. An example of a complex mathematical model in fluid mechanics  
p0182 N72 27308

**SOCIETE NATIONALE D'ETUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION, CORBEIL (FRANCE)**  
Materials development for high temperature turbines  
p0259 N71 17332

Application of the basic composites of carbon fibers and boron wire to compressor blades  
p0213 N73 27496

**SOCIETE NATIONALE D'ETUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION, VILLAROCHE (FRANCE)**  
High energy temperature turbine on turbines for gas turbines  
p0257 N71 17373

Temperature determinations in the blades of gas turbine cooled turbines  
p0257 N71 17375

Cracking of turbine distribution blades through impact attack  
p0260 N71 17347

Technical aspects of turbine blade cooling by Air Film  
p0261 N71 17401

Cycles of a gas turbine  
p0267 N71 26915

Influence of certain characteristic parameters upon performance  
p0264 N72 16695

Study of the design of compressors by finite element method of buckling  
p0213 N73 27499

# CORPORATE SOURCE INDEX

## SOCIETE NATIONALE D'ETUDES ET DE CONSTRUCTION DE MOTEURS AERONAUTIQUES, CORBEIL (FRANCE)

Materials currently employed in high temperature components of the aircraft gas turbine p0201 N73 23600

## SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE, COURBEVOIE (FRANCE)

Composites in engine structures and their adaptation to aircraft needs p0211 N73 27484

## SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE, MARIGNANE (FRANCE)

Fenestron: New solution of tail rotor p0048 N73 21028

## SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE, MARSEILLE (FRANCE)

Rotor stationary flight and large advancement parameters p0049 N73 21036

Rotor requirements beyond the usual flight domain of ONERA large wind tunnel at Mondonville p0049 N73 21 37

Measure of helicopter noise during flight p0052 N73 21055

Drag problems on rotary wing aircraft p0017 N73 22954

## SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE, PARIS (FRANCE)

A specialized documentation center: Its organization, its methods, its effectiveness p0113 N71 19529

An autonomous navigation system for helicopters p0032 N72 11929

Participation of the study of corrosion under tension of certain high resistance aluminum alloys p0288 N72 21921

A short survey on possibilities of fatigue life assessment of aircraft structures based on random or programmed fatigue tests p0291 N73 16897

Influence of the mass and mass distribution on flying qualities p0044 N73 16998

Ten years experience with the helicopter from operation in French Army p0046 N73 21011

Some thoughts on the SA 341 Gazelle speed record p0047 N73 21018

Inertialess flight methods p0280 N73 23895

Discrepancy between approval and modernization p0053 N73 24050

Designers need for general information from analysis of fatigue test results and service behavior p0061 N74 19660

Techniques oriented towards cost reduction p0335 N74 21013

## SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE, TOULOUSE (FRANCE)

Cockpit environment p0171 N71 16365

Influence of the design and functioning characteristics of the flying control system of a transport aircraft on its flight qualities p0040 N72 32032

Keynote address p0292 N73 29906

Experimental research on the response of aircraft structures to acoustic fatigue p0293 N73 29913

## SOCIETE NOUVELLE DES ACIERIES DE POMPEY (FRANCE)

Investigation of an accelerated stress corrosion cracking method p0288 N72 21924

## SOCIETE TREFIMETAL ARGENTEUIL (FRANCE)

Characterization: selection and use of titanium base alloys p0206 N71 27045

## SOLAR, SAN DIEGO, CALIF.

The composite microstructure and protection afforded by several commercial coatings on two nickel base alloys [NASA CR 116374] p0259 N71 17393

## SOUTHAMPTON UNIV. (ENGLAND)

Generation of intermodulation interference due to non-linear effects in the near field region of multiple transmitters on communication systems p0134 N73 10212

Estimates of the response of box type structures to acoustic loading p0293 N72 29915

Computer aided analysis of electronic circuits on a small machine p0167 N74 13925

## SOUTHWEST RESEARCH INST. SAN ANTONIO, TEX.

Emulsified fuels and aircraft safety p0253 N72 11688

## SPERRY RAND CORP. ST. PAUL, MINN.

Aerobase computer memory techniques p0156 N72 21218

## STANDARD ELECTRIK LORENZ A.G. STUTTGART (WEST GERMANY)

Programs in PCM memory for order display applications p0193 N72 19504

## STANFORD RESEARCH INST. CALIF.

Satellite power distribution as a function of orbital propagation conditions p0174 N71 21114

## STANFORD RESEARCH INST. MENLO PARK, CALIF.

Polar propagation effects on VLF radio data p0126 N72 21126

Aircrew radio backscatter studies from Alaska p0127 N72 21129

Frequency distribution of aircraft HF propagation p0129 N72 21143

Model studies for the prediction of aircraft HF propagation p0136 N73 14144

Comparison of computer and experimental studies on HF propagation near surface irregularities p0137 N73 14159

Nonlinear wave effects on HF propagation p0138 N73 14169

The effects of ionospheric irregularities on HF propagation waves on HF communication systems p0140 N73 14170

## STANFORD UNIV. CALIF.

Tropospheric influence upon diffraction paths p0117 N71 21450

Angle and Doppler measurements of the specular and scattered components of transhorizon microwave signals p0117 N71 23453

Some considerations relative to the prediction of unsteady air loads on interfering surfaces p0007 N71 29334

Compact heat exchangers p0299 N72 18947

The suppression of shear layer turbulence in rotating systems p0180 N72 20305

HF measurements of ocean wave directional spectra p0145 N74 13867

Application of a general method for flutter optimization p0297 N74 15609

## STEINHEIL LEAR SIEGLER & G. ISMANING (WEST GERMANY)

A three axis gyro stabilized torpedo platform p0230 N73 20702

## STRASBOURG UNIV. (FRANCE)

Aeronautical factors and toothache incidences during flight p0092 N71 22309

## STRATHCLYDE UNIV. GLASGOW (SCOTLAND)

The mechanical and structural characteristics of concrete tie tissue p0101 N72 19140

## STUTTGART UNIV. (WEST GERMANY)

Present and future possibilities of high strength and stiffness to weight ratio composites in primary structures p0211 N73 27481

## SUD AVIATION, TOULOUSE (FRANCE)

An weather Sud Lear landing system installed on the Caravelle p0030 N71 23429

## SUPERTECHNOLOGY CORP. BOSTON, MASS.

Stability of a superconductor as influenced by the substrate p0063 N73 19031

## SUSSEX UNIV. BRIGHTON (ENGLAND)

Heat transfer instrumentation p0257 N71 17377

Transpiration cooled turbines p0258 N71 17383

## SYSTEMS CONTROL INC. PALO ALTO, CALIF.

An ATC surveillance modeling approach for specifying lane separation standards p0233 N73 23699

Current state of modeling for the human operator as a controller: Decision maker in manned aerospace systems p0280 N73 23827

## SYSTEMS TECHNOLOGY INC. HAWTHORNE, CALIF.

Systematic manual control display design [NASA CR 126256] p0223 N72 22627

# T

## TECHNICAL UNIV. OF DENMARK, LYNGBY

Pattern recognition using dynamic pictorial information p0155 N72 11206

An experimental investigation of curved two dimensional turbulent jets p0178 N72 20294

On the polarizing E Condition its implications morphological and relationship to other interfacial phenomena p0130 N72 21148

On residual stresses during random load fatigue p0291 N73 16302

Improved data for propagation analysis p0141 N73 26132

Extrapolation of propagation data p0142 N73 26133

The feasibility of CACA in Denmark p0155 N74 13932

Computer aided design of maximum production yield or maximum reliability p0165 N74 13911

Optimal joint positions for space trusses p0297 N74 15608

## TECHNISCHE HOCHSCHULE, AACHEN (WEST GERMANY)

Experimental investigation on a single stage air cooled gas turbine p0259 N71 17387

A new concept of the heat design of the thermodynamic cycle of the turbofan engine at high flight Mach numbers p0267 N72 16717

Application of boundary layer theory in turbomachinery p0270 N73 12819

Acoustic wave interaction layers in axial flow turbomachinery p0270 N73 19814

Modeling of deformation of stiffened structures under temperature loads p0298 N74 15616

Numerical treatment of boundary layer problems p0185 N74 22918

## TECHNISCHE HOCHSCHULE, DARMSTADT (WEST GERMANY)

The effects of the earth's magnetic field on optical satellite communication links p0244 N73 16937

## TECHNISCHE HOCHSCHULE, STUTTGART (WEST GERMANY)

Rotational dynamics p0277 N72 12812

Design of airfoils with high lift at low and medium subsonic Mach numbers p0242 N71 15364

## TECHNISCHE HOOGESCHOOL TWENTE, ENSCHEDE (NETHERLANDS)

Determination of shock orientations from acoustic measurements p0270 N72 20192

## TECHNISCHE HOOGESCHOOL DELFT (NETHERLANDS)

Self and drag characteristics of delta wing half model configurations with various leading edge suction devices p0272 N73 19359

The storage of inter information in a memory p0154 N72 11197

# TEXAS UNIV., AUSTIN

The determination of stability derivatives and performance characteristics from dynamic manoeuvres p0031 N72 20992

Pilot vehicle analysis p0040 N72 32034

Some research on two dimensional laminar separation bubbles p0041 N73 15000

An analytical expression for the balanced field length p0063 N73 24051

DAP (Distribution Analysis Program): A program for the analysis and design of microwave circuits p0186 N74 13921

## TECHNISCHE HOOGESCHOOL EINDHOVEN (NETHERLANDS)

Introductory survey to session 3: Control of antennae side lobes p0147 N74 13857

Some aspects of near and far angle sidelobes in double reflector antennas p0147 N74 13858

## TECHNISCHE UNIV. BERLIN (WEST GERMANY)

An integral method for approximate calculation of compressible turbulent boundary layers with streamwise pressure gradient p0178 N72 20278

Optimization of the layout of trusses combining strategies based on Michell's theorem and on the biological principles of evolution p0298 N74 15817

## TECHNISCHE UNIVERSITAET, BRUNSWICK (WEST GERMANY)

Aerodynamics of pneumatic high lift device p0025 N71 20053

The effect of axial velocity ratio on the aerodynamic coefficients of a compressor cascade in viscous flow p0269 N73 19804

Experience with composites as obtained from gliders p0111 N73 27486

## TELOUX LUFTFAHRT AUSBAUEINSTUFGUNG G. & H. HEIDELBERG (WEST GERMANY)

The DRALLRAD: A flywheel for the synchronization of synchronous satellites p0191 N72 19493

Systems tasks for advanced aircraft navigation systems p0156 N72 21222

Investigations on the optimization of avionic navigation systems p0223 N73 20694

## TELEDYNE SYSTEMS CO., NORTHBRIDGE, CALIF.

An integrated low altitude flight control system for helicopters p0032 N72 11924

Guidance and control computer system design p0155 N72 21214

Aerospace computer input/output techniques p0156 N72 21219

Helicopter guidance and control computer systems p0156 N72 21223

Dynamically tuned gyros in strapdown systems p0229 N73 20697

## TENNESSEE UNIV., TULLAHOMA

Unsteady aerodynamic effects of rotor blades of a compressor under distorted flow conditions p0003 N71 19370

An introduction to the laser p0199 N72 25422

Principles of holography p0199 N72 25445

Mathematical methods in coherent optical systems analysis: First order analysis of a holographic interferometer system p0199 N72 25496

## TENNESSEE UNIV. SPACE INST., TULLAHOMA

Review of data and prediction techniques for wind profiles around man made surface obstructions p0057 N74 17724

## TEST GROUP (8585TH) HOLLOWMAN AFB, NMEX.

Static pull scale measurements of RCS p0144 N74 11957

Prevention and storage of radar cross section data p0145 N74 11954

## TETRA TECH INC. PASADENA, CALIF.

Reflective index fluctuations in sea water p0241 N73 33625

Theory of small angle scattering p0242 N73 33628

Experimental results of small angle scattering p0242 N73 33629

Factors affecting long range vision p0242 N73 33630

Criteria for Visual Resolution signal to noise ratio contrast p0242 N73 33631

Modulation system transfer functions p0242 N73 33632

Sea waves: Air-Sea interaction in 11 layer lamps p0242 N73 33633

Reviews: Photographic and photographic detection p0242 N73 33634

Long Range vision in the sea p0242 N73 33635

Spatial Filtering in image restoration p0242 N73 33637

FORTRAN 4 algorithms for underwater optics p0243 N73 33638

## TEXAS A&M UNIV., COLLEGE STATION

Unsteady aerodynamics of helicopter rotors p0177 N73 14001

## TEXAS INSTRUMENTS INC. DALLAS

Synthesis and evaluation of an optimum sampled data FM demodulator p0131 N73 10195

## TEXAS UNIV., AUSTIN

Comparison of 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900, 910, 920, 930, 940, 950, 960, 970, 980, 990, 1000, 1010, 1020, 1030, 1040, 1050, 1060, 1070, 1080, 1090, 1100, 1110, 1120, 1130, 1140, 1150, 1160, 1170, 1180, 1190, 1200, 1210, 1220, 1230, 1240, 1250, 1260, 1270, 1280, 1290, 1300, 1310, 1320, 1330, 1340, 1350, 1360, 1370, 1380, 1390, 1400, 1410, 1420, 1430, 1440, 1450, 1460, 1470, 1480, 1490, 1500, 1510, 1520, 1530, 1540, 1550, 1560, 1570, 1580, 1590, 1600, 1610, 1620, 1630, 1640, 1650, 1660, 1670, 1680, 1690, 1700, 1710, 1720, 1730, 1740, 1750, 1760, 1770, 1780, 1790, 1800, 1810, 1820, 1830, 1840, 1850, 1860, 1870, 1880, 1890, 1900, 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1980, 1990, 2000, 2010, 2020, 2030, 2040, 2050, 2060, 2070, 2080, 2090, 2100, 2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190, 2200, 2210, 2220, 2230, 2240, 2250, 2260, 2270, 2280, 2290, 2300, 2310, 2320, 2330, 2340, 2350, 2360, 2370, 2380, 2390, 2400, 2410, 2420, 2430, 2440, 2450, 2460, 2470, 2480, 2490, 2500, 2510, 2520, 2530, 2540, 2550, 2560, 2570, 2580, 2590, 2600, 2610, 2620, 2630, 2640, 2650, 2660, 2670, 2680, 2690, 2700, 2710, 2720, 2730, 2740, 2750, 2760, 2770, 2780, 2790, 2800, 2810, 2820, 2830, 2840, 2850, 2860, 2870, 2880, 2890, 2900, 2910, 2920, 2930, 2940, 2950, 2960, 2970, 2980, 2990, 3000, 3010, 3020, 3030, 3040, 3050, 3060, 3070, 3080, 3090, 3100, 3110, 3120, 3130, 3140, 3150, 3160, 3170, 3180, 3190, 3200, 3210, 3220, 3230, 3240, 3250, 3260, 3270, 3280, 3290, 3300, 3310, 3320, 3330, 3340, 3350, 3360, 3370, 3380, 3390, 3400, 3410, 3420, 3430, 3440, 3450, 3460, 3470, 3480, 3490, 3500, 3510, 3520, 3530, 3540, 3550, 3560, 3570, 3580, 3590, 3600, 3610, 3620, 3630, 3640, 3650, 3660, 3670, 3680, 3690, 3700, 3710, 3720, 3730, 3740, 3750, 3760, 3770, 3780, 3790, 3800, 3810, 3820, 3830, 3840, 3850, 3860, 3870, 3880, 3890, 3900, 3910, 3920, 3930, 3940, 3950, 3960, 3970, 3980, 3990, 4000, 4010, 4020, 4030, 4040, 4050, 4060, 4070, 4080, 4090, 4100, 4110, 4120, 4130, 4140, 4150, 4160, 4170, 4180, 4190, 4200, 4210, 4220, 4230, 4240, 4250, 4260, 4270, 4280, 4290, 4300, 4310, 4320, 4330, 4340, 4350, 4360, 4370, 4380, 4390, 4400, 4410, 4420, 4430, 4440, 4450, 4460, 4470, 44

# TEXAS UNIV. GALVESTON

- TEXAS UNIV. GALVESTON**  
Impulsiveness and anxiety related to peripheral motor performance p0069 N71 2031
- THOMSON CSF. BAGNEUX (FRANCE)**  
Role of simulations in the study and development of the CROTAL system p0237 N74 1435
- TORONTO UNIV. (ONTARIO)**  
Optokinetic nystagmus: its value in the diagnosis of central vestibular lesions p0109 N74 20742
- TOULOUSE UNIV. (FRANCE)**  
Evidence on the effect of natural ionizing radiation on biological stimulation p0075 N72 26050  
Microwave circuit analysis by digital computer p0166 N74 13922
- TRANSCOATES LTD., LONDON (ENGLAND)**  
Education and technical training for technical information p0160 N74 16931
- TRANSPORTATION SYSTEMS CENTER, CAMBRIDGE, MASS**  
Automatic detection of vehicles in aerial photographs of highways p0152 N72 11183  
The detection of aircraft wake vortices p0058 N74 17731
- TW SYSTEMS GROUP, REDONDO BEACH, CALIF**  
Sea brightness temperatures at microwave frequencies p0124 N72 16112  
Computers for satellite based navigation and guidance systems p0157 N72 21226  
Pulsed laser holography [NASA CR 126767] p0199 N72 25501  
Ruby laser holography p0200 N72 25502  
Concurrent analysis of ICNI systems p0235 N72 23719
- TULANE UNIV. NEW ORLEANS, LA**  
Clinical application of nystagmography p0108 N74 20733
- TYCO LABS. INC. WALTHAM, MASS**  
Measuring the degree of conjoint action between stress and corrosion in stress corrosion p0286 N72 21908

# U

- ULM UNIV. (WEST GERMANY)**  
Computer electronystagmography in evaluating the influence of psychopharmacological drugs on vigilance p0109 N74 20749
- UNION CARBIDE CORP., TARRYTOWN, NY**  
High field plasma arc plated Nb3Sn superconductor solenoids p0063 N73 19034
- UNITED AIRCRAFT CORP., EAST HARTFORD, CONN**  
Practical calculations of transitional boundary layers p0268 N73 19796  
Rotor wakes: Key to performance prediction p0049 N73 21032
- UNITED AIRCRAFT CORP., STRATFORD, CONN**  
A feasible fuel augmentation system for helicopters p0033 N72 11931  
Impact of new structural concepts on system capabilities p0048 N73 21021  
Development of the ABC rotor p0048 N73 21029  
Aerodynamic factors influencing overall hover performance p0050 N73 21038  
Helicopter rotor loads predictions p0056 N74 10912
- UNITED AIRCRAFT OF CANADA, LTD., LONGUEUIL (QUEBEC)**  
An experimental cooled radial turbine p0259 N71 17391  
The state of the art of small gas turbine engines for helicopters and surface transport p0262 N71 26953
- UNITED KINGDOM ATOMIC ENERGY AUTHORITY, HARWELL (ENGLAND)**  
The Harwell heat transfer and fluid flow information analysis centre p0113 N71 19530
- UNITED STATES STEEL CORP., MONROEVILLE, PA**  
Microscopic identification of stress corrosion cracking in steels with high yield strength p0289 N72 21925
- UNIVERSIDADE TECNICA DE LISBOA (PORTUGAL)**  
Nucleon number effects in turbulent flow p0178 N72 26282
- UNIVERSITY COLL. LONDON (ENGLAND)**  
Cellular logic and its significance in pattern recognition p0154 N72 11198
- UNIVERSITY OF SOUTHERN CALIF., LOS ANGELES**  
Intermittent structures in turbulent boundary layers p0175 N72 20272
- UNIVERSITY OF SOUTHERN CALIF., MARINA DEL REY**  
A parallel printed circuit board design system p0168 N74 13936
- UNIVERSITY OF TECHNOLOGY, LEICESTER (ENGLAND)**  
The effects of breathing on respiratory gas exchange p0204 N73 19972
- UPPSALA IONOSPHERIC OBSERVATORY (SWEDEN)**  
Traveling ionospheric disturbances correlated by low altitude nuclear explosions p0119 N73 14166
- UPPSALA UNIV. (SWEDEN)**  
Boundary conditions for differential approximation of hyperbolic differential equations p0185 N74 22315

# V

- VANDERBILT UNIV., NASHVILLE, TENN**  
A man-machine approach toward solving various routing scheduling and network problems p0154 N72 11139
- VEREINIGTE FLUGTECHNISCHE WERKE GMBH BREMEN (WEST GERMANY)**  
Velocity and density measurements in a free jet p0178 N72 25293  
VAK 191 B experimental program for a V-STOL aircraft p0054 N73 27006
- VEREINIGTE FLUGTECHNISCHE WERKE FOKKER GMBH BREMEN (WEST GERMANY)**  
Evaluation of an integrated flight display for the manual IFR landing of VTOL aircraft p0224 N72 22631
- VEREINIGTE FLUGTECHNISCHE WERKE FOKKER GMBH MUNICH (WEST GERMANY)**  
Subsonic unsteady airloads on multiple lifting surfaces p0008 N72 29339  
Tail aeroelastic analysis for Fokker F 28 p0009 N71 29344
- VIRGINIA POLYTECHNIC INST., BLACKSBURG**  
Effects of strong axial pressure gradients on turbulent boundary layer flows [NASA CR 125903] p0176 N72 20281
- VON KARMAN INST. FOR FLUID DYNAMICS, RHODE SAINT GENESE (BELGIUM)**  
Design of small diameter turbine blade by theoretical analysis p0258 N71 17380  
Application of film cooling to gas turbine blades p0260 N71 17394  
Fundamental aspects of flow separation under high lift conditions p0025 N71 20055  
Flow analysis in axisymmetric subsonic inlets of small gas turbines p0265 N72 16701  
Introductory remarks p0181 N72 27294  
On the two dimensional boundary layers as they appear on turbomachine blades p0266 N73 19795  
Blade optimization based on boundary layer concepts p0269 N73 19801  
Secondary flow research at the von Karmán Institute p0270 N73 19811  
Shock wave boundary layer interaction in cascades p0271 N73 19816  
Review of some problems related to the design and operation of low speed wind tunnels for V-STOL testing p0173 N73 26240  
Numerical integration of Navier-Stokes equations p0185 N74 22917
- VOUGHT AERONAUTICS, DALLAS, TEX**  
Application of solid state switching and multiplexing to aircraft electrical systems p0056 N73 19053

# W

- WALTER REED ARMY MEDICAL CENTER, WASHINGTON, D.C.**  
Predicting visual performance in aviators' color vision p0078 N73 19074
- WARREN SPRING LAB., STEVENAGE (ENGLAND)**  
Relative air pollution emissions from an airport in the UK and neighboring urban areas p0218 N74 14282
- WARWICK UNIV., COVENTRY (ENGLAND)**  
The behaviour of composite superconducting materials under ac conditions p0063 N73 19032
- WASHINGTON UNIV., SEATTLE**  
Multiple scattering effects on wave propagation through rain p0140 N73 26172
- WASHINGTON UNIV., ST. LOUIS, MO**  
Robot data screening: An intelligent data search technique p0151 N72 11176
- WEAPONS RESEARCH ESTABLISHMENT, SALISBURY (AUSTRALIA)**  
Ionospheric tilt measurements near the magnetic equator p0138 N73 14160  
X-ray tracing of gravity wave perturbed ionospheric profiles p0139 N73 14163
- WELDING INST., CAMBRIDGE (ENGLAND)**  
Stress corrosion testing of welded joints p0286 N72 21910
- WESTERN ONTARIO UNIV., LONDON**  
Longitudinal waves in airways p0122 N72 21132  
Angular deviation of radio waves p0128 N72 21139
- WESTINGHOUSE ELECTRIC CORP., PITTSBURGH, PA**  
Superconducting wire for a high speed p0064 N71 19030
- WESTINGHOUSE RESEARCH LABS., PITTSBURGH, PA**  
An apparatus for stress corrosion testing with large precracked WDC specimens p0297 N73 21974
- WESTLAND AIRCRAFT LTD., YEovil (ENGLAND)**  
The structure of the rotor blade root p0049 N73 21034
- WESTLAND HELICOPTERS LTD., HAYES (ENGLAND)**  
Use of composites in helicopter: Advantages and disadvantages p0211 N73 27481
- WESTLAND HELICOPTERS LTD., YEovil (ENGLAND)**  
Ground and flight test experience with the Westland Sea King helicopter p0147 N73 21072  
Materials for a low cost rotorcraft p0148 N73 21073  
The use of a water tank for a large scale model p0057 N73 21059

# CORPORATE SOURCE INDEX

- Flight testing for performance and flying qualities p0018 N73 22959  
Wind tunnel requirements for helicopters p0173 N73 26246  
The prediction of loading actions on high speed semi-rigid helicopters p0056 N74 10914
- WILCOX ELECTRIC CO., INC., KANSAS CITY, MO**  
Decisions for the 70's p0232 N73 23692
- WISCONSIN UNIV., MADISON**  
The identification of inhomogeneous media from transient diffusion of electromagnetic fields p0125 N72 16118
- WISCONSIN UNIV., MIDDLETON**  
Electromagnetic sounding of ice thickness p0123 N72 16099  
Effect of beam width on acoustic signals scattered at a rough surface p0123 N72 16102
- WRIGHT CO., KETTERING, OHIO**  
Armor materials for life support p0102 N72 19143
- WRIGHT STATE UNIV., DAYTON, OHIO**  
Vibration p0076 N72 17099  
Noise p0076 N73 17100

# Y

- YALE UNIV., NEW HAVEN, CONN**  
Environmental effects on gas-metal reactions at elevated temperatures p0202 N73 23606

# Z

- ZENTRALSTELLE FUER MASCHINELLE DOKUMENTATION (ZMD), FRANKFURT (WEST GERMANY)**  
Problems of data recording and data interchange p0159 N73 24207

## AGARD INDEX OF PUBLICATIONS (1971-1973)

**REPORT  
NUMBER**

NASA  
ACCESSION  
NUMBER

00145

Nº 4 13846

PAGE  
NUMBER

**MICROFICHE  
SYMBOL**

AGARD AR 42 REV  
AGARD AR 43  
AGARD AR 44  
AGARD AR 45  
AGARD AR 46  
AGARD AR 47 VOL 1  
AGARD AR 47 VOL 2  
AGARD AR 47 VOL 3  
AGARD A 3 49  
AGARD AR 49  
AGARD AS 5  
AGARD AR 51  
AGARD AP 52  
AGARD AR 53  
AGARD AP 54  
AGARD AH 56  
AGARD AR 57 VOL 1  
AGARD AR 57 VOL 2  
AGARD AR 57 VOL 1  
AGARD AR 58  
AGARD AR 60  
AGARD AP 61  
AGARD AR 62  
AGARD AR 63

AGARD CP 63  
AGARD CP 70  
AGARD CP 70 FT 1  
AGARD CP 71  
AGARD CP 72  
AGARD CP 73  
AGARD CP 76  
AGARD CP 78  
AGARD CP 79  
AGARD CP 80 PT 1  
AGARD CP 80 PT 2  
AGARD CP 81  
AGARD CP 82  
AGARD CP 82  
AGARD CP 84  
AGARD CP 85  
AGARD CP 86  
AGARD CP 87

AGARD AG 137 PT 3	00175 N72 15269
AGARD AG 148	00299 N72 12950
AGARD AG 149	00283 N71 20128
AGARD AG 150	00094 N71 23337
AGARD AG 151	00076 N73 17098
AGARD AG 152	00205 N71 20027
AGARD AG 153	00067 N71 20076
AGARD AG 154	00071 N72 14058
AGARD AG 154-FR1	00089 N74 27277
AGARD AG 155	00285 N72 18882
AGARD AG 156	00016 N72 22001
AGARD AG 157	00290 N72 27918
AGARD AG 158	00155 N72 21271
AGARD AG 159	00186 N72 25346
AGARD AG 160 VOL 2	00196 N73 26499
AGARD AG 160 VOL 3	00204 N73 26420
AGARD AG 160 VOL 4	00196 N74 14116
AGARD AG 161	00299 N72 24959
AGARD AG 162 PT 1	00290 N72 23893
AGARD AG 162 PT 2	00298 N73 14858
AGARD AG 162 PT 3	00298 N74 19550
AGARD AG 163	00283 N73 17248
AGARD AG 164	00268 N73 19734
AGARD AG 165	00190 N73 21945
AGARD AG 166	00182 N72 23356
AGARD AG 166A	00187 N74 14084
AGARD AG 167	00207 N73 26800
AGARD AG 168	00111 N73 21833
AGARD AG 168 FQ.	00107 N74 22199
AGARD AG 169	00184 N74 22642
AGARD AG 170	00284 N74 27748
AGARD AG 171	00218 N74 23211
AGARD AG 172	00208 N74 23705
AGARD AG 173	00184 N74 18921
AGARD AG 174	00184 N74 18123

A <sub>1</sub> APD A <sub>1</sub> 29	1263 472 1699
A <sub>1</sub> APD A <sub>1</sub> 31	1299 472 1538
A <sub>1</sub> APD A <sub>1</sub> 32	1265 472 1512
A <sub>1</sub> APD A <sub>1</sub> 33	1230 472 2138
A <sub>1</sub> APD A <sub>1</sub> 34	1289 472 1345
A <sub>1</sub> APD A <sub>1</sub> 35	1235 472 2073
A <sub>1</sub> APD A <sub>1</sub> 36	1299 472 1640
A <sub>1</sub> APD A <sub>1</sub> 37	1272 472 1762
A <sub>1</sub> APD A <sub>1</sub> 38	1299 472 1966
A <sub>1</sub> APD A <sub>1</sub> 39	1235 472 1245
A <sub>1</sub> APD A <sub>1</sub> 40	1212 472 1599
A <sub>1</sub> APD A <sub>1</sub> 41	1267 472 2189
A <sub>1</sub> APD A <sub>1</sub> 42	1243 472 1348

c0149 x74 73499  
 p0194 x72 25419 #  
 c0255 x72 27811 #  
 p0290 x72 28902 #  
 p0182 x73 11262 #  
 p0081 x74 73500 #  
 l0081 x74 73501 #  
 p0081 x74 73502 #  
 l0041 x73 13018 #  
 p0046 x73 18023 #  
 p0063 x73 18061 #  
 c0198 x73 18439 #  
 p0292 x73 18931 #  
 p0140 x73 23108 #  
 c0292 x73 28884 #  
 p0057 x74 12713 #  
 p0307 x74 73504 #  
 p0307 x74 73505 #  
 p0306 x74 73503 #  
 p0018 x74 73905 #  
 p0172 x73 23269 #  
 p0052 x73 21931 #  
 c0055 x73 31954 #  
 c0222 x74 15349 #

p0206 n72 12 492 \*  
 p0207 n72 12 2345 \*  
 p0214 n72 12 409 \*  
 p0091 n71 12 353 \*  
 p0161 n74 12 73506 \*  
 p0257 n71 12 1372 \*  
 p0207 n72 12 21410 \*  
 p0113 n71 12 19526 \*  
 p0177 n71 12 16680 \*  
 p0207 n71 12 19333 \*  
 p0008 n71 12 19338 \*  
 p0091 n71 12 22301 \*  
 p0067 n71 12 20351 \*  
 p0111 n72 12 11854 \*  
 p0251 n72 12 11668 \*  
 p0034 n72 12 20976 \*  
 p0030 n72 12 11915 \*  
 p0190 n72 12 19483 \*  
 p0098 n72 12 19119 \*  
 p0095 n72 12 14092 \*  
 p0121 n72 12 16085 \*  
 p0263 n72 12 15685 \*  
 p0157 n72 12 11768 \*  
 p0215 n72 12 20273 \*  
 p0051 n72 12 11174 \*  
 p0071 n72 12 21331 \*  
 p0227 n72 12 25040 \*  
 p0205 n72 12 2604 \*  
 p0273 n72 12 22621 \*  
 p0126 n72 12 11121 \*  
 p0285 n72 12 19100 \*  
 p0077 n73 12 19656 \*  
 p0102 n73 12 19959 \*  
 p0104 n73 12 19143 \*  
 p0041 n73 12 14998 \*  
 p0130 n73 12 19187 \*  
 p0063 n73 12 19230 \*  
 p0128 n73 12 23589 \*  
 p0232 n73 12 37013 \*

93078 473 21107  
 93079 473 21392  
 93081 473 23557  
 93049 473 23035  
 93125 473 23474  
 93292 473 25935  
 93088 473 23881  
 93034 473 14131  
 93222 473 26584  
 93158 473 24201  
 93291 473 26896  
 93243 473 26989  
 93031 473 23537  
 93466 473 25008  
 93095 474 15948  
 93295 474 15596  
 93358 474 15749  
 93217 474 24213  
 93054 473 27336  
 93662 474 35577  
 93445 474 31646  
 93597 474 20732  
 93084 474 13784  
 93565 474 23906  
 93106 474 18747  
 93088 474 18749  
 93159 474 15925

AGARD CP 140  
AGARD CP 141

AGARD LS 43  
AGARD LS 44  
AGARD LS 45  
AGARD LS 46  
AGARD LS 47  
AGARD LS 48  
AGARD LS 49  
AGARD LS 50  
AGARD LS 51  
AGARD LS 52  
AGARD LS 53  
AGARD LS 54  
AGARD LS 55  
AGARD LS 56  
AGARD LS 57  
AGARD LS 58  
AGARD LS 59  
AGARD LS 60  
AGARD LS 61  
AGARD LS 62  
AGARD LS 63  
AGARD LS 64

AGAPD R 577 P 12  
AGAPD R 578  
AGAPD R 579  
AGAPD R 580  
AGAPD R 581  
AGAPD R 582  
AGAPD R 583  
AGAPD R 584  
AGAPD R 585  
AGAPD R 586  
AGAPD R 587  
AGAPD R 588  
AGAPD R 589  
AGAPD R 590  
AGAPD R 591  
AGAPD R 592  
AGAPD R 593  
AGAPD R 594  
AGAPD R 595  
AGAPD R 596  
AGAPD R 597  
AGAPD R 598  
AGAPD R 599  
AGAPD R 600  
AGAPD R 601  
AGAPD R 602  
AGAPD R 603  
AGAPD R 604  
AGAPD R 605  
AGAPD R 606  
AGAPD R 607  
AGAPD R 608  
AGAPD R 609  
AGAPD R 610  
AGAPD R 611  
AGAPD R 612  
AGAPD R 613

AGAR000GAPRPH 13 P1 3  
AGAR000GAPRPH 148  
AGAR000GAPRPH 149  
AGAR000GAPRPH 150  
AGAR000GAPRPH 151  
AGAR000GAPRPH 152  
AGAR000GAPRPH 153  
AGAR000GAPRPH 154  
AGAR000GAPRPH 155  
AGAR000GAPRPH 156  
AGAR000GAPRPH 157  
AGAR000GAPRPH 158  
AGAR000GAPRPH 159  
AGAR000GAPRPH 160  
AGAR000GAPRPH 161  
AGAR000GAPRPH 162 P1  
AGAR000GAPRPH 163 P1  
AGAR000GAPRPH 164 P1  
AGAR000GAPRPH 165  
AGAR000GAPRPH 166  
AGAR000GAPRPH 167  
AGAR000GAPRPH 168

0057 474 17720 #  
0060 474 19652 #

p0025	471	20051	*
p0301	471	23501	*
p0277	472	12861	*
p0261	471	26951	*
p0189	471	36776	*
p0181	472	27293	*
p0199	472	25493	*
p0195	471	10450	*
p0205	471	27038	*
p0226	472	27681	*
p0037	472	27016	*
p0661	474	26234	*
p0209	472	29589	*
p0502	473	24042	*
p0299	472	18946	*
p0143	473	32053	*
p0143	474	1354	*
p0236	474	14345	*
p0241	473	33639	*
p0294	473	29924	*
p0017	473	22948	*
p0184	474	22914	*

00055 \*73 27936  
00060 \*73 27980  
00063 \*73 28080  
00066 \*71 23210  
00085 \*71 25449  
00189 \*71 20002  
00190 \*71 35198  
00172 \*71 34253  
00302 \*71 36382  
00217 \*72 11511  
00197 \*72 19541  
00016 \*72 7978  
00034 \*72 15958  
00290 \*71 24934  
00201 \*72 20491  
00290 \*72 33915  
00040 \*73 11020  
00196 \*73 11407  
00016 \*73 14000  
00046 \*73 18030  
00041 \*73 13019  
00182 \*72 33267  
00017 \*73 17196  
00173 \*74 16987  
00172 \*73 26218  
00173 \*73 26739  
00173 \*73 18250  
00292 \*73 19166  
00046 \*73 20023  
00300 \*73 25968  
00052 \*73 21920  
00055 \*71 27895  
00034 \*74 17664  
00074 \*74 27118  
00024 \*74 18652  
00023 \*74 18713  
00023 \*74 18674

p=255 732 12569  
 p=259 732 12560  
 p=263 731 20178  
 p=264 731 23377  
 p=266 733 13398  
 p=265 732 20277  
 p=267 731 20166  
 p=268 732 14588  
 p=269 734 20177  
 p=285 732 13882  
 p=286 732 22983  
 p=290 732 22988  
 p=295 732 20177  
 p=287 732 20175  
 p=296 731 20169  
 p=294 732 20168  
 p=299 732 14588  
 p=299 732 24355  
 p=299 732 20167  
 p=299 733 18988  
 p=299 732 20168  
 p=303 733 15242  
 p=306 733 14588  
 p=306 733 14594  
 p=306 732 20165  
 p=302 731 20168  
 p=302 734 14584  
 p=302 733 20168

# R E P O R T

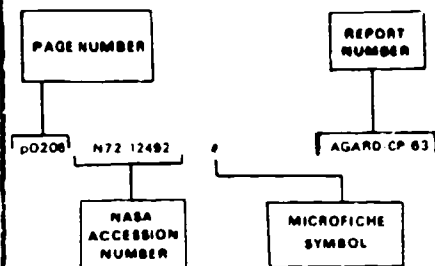
REPORT/ACCESSION NUMBER INDEX

AGARDOGRAPH 168	p0111 N73 21830	#
AGARDOGRAPH 168(FR)	p0111 N74 22799	#
AGARDOGRAPH 169	p0184 N74 12042	#
AGARDOGRAPH 170	p0084 N74 12748	#
AGARDOGRAPH 171	p0018 N74 13710	#
AGARDOGRAPH 172	p0018 N74 13709	#
AGARDOGRAPH 173	p0184 N74 18923	#
AGARDOGRAPH 174	p0184 N74 18324	#

# ACCESSION/REPORT NUMBER INDEX

GARD INDEX OF PUBLICATIONS (1971-1973)

## TYPICAL ACCESSION REPORT NUMBER INDEX LISTING



Listings in this index are arranged numerically by NASA accession number. The page number identifies the page in the abstract section (Part I) on which the citation appears. All report numbers that were cataloged are listed. A pound sign (#) indicates that the item is available on microfiche. A plus sign (+) indicates that the document was not microfilmed but that a one-to-one facsimile copy may be available. Microfiche or hard copy are available from the purchase agencies listed on the back cover.

NOTE: "NO REPORT NUMBER" indicates that the reference is one of the papers contained in the AGARD Series Number preceeding it, e.g., p0171 N 71-16061 # is contained in AGARD CP-79-70. Papers which also possess a reference number in a non-AGARD report series have been identified, e.g., "p0172 N 71 16069 # NASA-TM-X-66583", but such papers are also contained in the preceeding AGARD Series Number (e.g., in this case, AGARD CP-79-70).

p0171	N71 16060	AGARD CP 79 70
p0171	N71 16061	NO REPORT NUMBER
p0171	N71 16062	NO REPORT NUMBER
p0171	N71 16063	NO REPORT NUMBER
p0171	N71 16064	NO REPORT NUMBER
p0171	N71 16065	NO REPORT NUMBER
p0171	N71 16066	NO REPORT NUMBER
p0172	N71 16067	NO REPORT NUMBER
p0172	N71 16068	NO REPORT NUMBER
p0172	N71 16069	NASA TM X 66583
p0257	N71 17372	AGARD CP 73 71
p0257	N71 17373	NO REPORT NUMBER
p0257	N71 17374	NO REPORT NUMBER
p0257	N71 17375	NO REPORT NUMBER
p0257	N71 17376	NO REPORT NUMBER
p0257	N71 17377	NO REPORT NUMBER
p0257	N71 17378	NO REPORT NUMBER
p0257	N71 17379	NO REPORT NUMBER
p0258	N71 17380	NO REPORT NUMBER
p0258	N71 17381	NO REPORT NUMBER
p0258	N71 17382	NO REPORT NUMBER
p0258	N71 17383	NO REPORT NUMBER
p0258	N71 17384	NO REPORT NUMBER
p0258	N71 17385	NASA TM X 66702
p0258	N71 17386	NO REPORT NUMBER
p0259	N71 17387	NO REPORT NUMBER
p0259	N71 17388	NASA CR 118376
p0259	N71 17389	NO REPORT NUMBER
p0259	N71 17390	NO REPORT NUMBER
p0259	N71 17391	NO REPORT NUMBER
p0259	N71 17392	NO REPORT NUMBER
p0259	N71 17393	NASA CR 118374
p0260	N71 17394	NO REPORT NUMBER
p0260	N71 17395	NO REPORT NUMBER
p0260	N71 17396	NO REPORT NUMBER
p0260	N71 17397	NO REPORT NUMBER
p0260	N71 17398	NO REPORT NUMBER
p0260	N71 17399	NO REPORT NUMBER
p0260	N71 17400	NO REPORT NUMBER

p0261	N71 17401	NO REPORT NUMBER
p0261	N71 17402	NO REPORT NUMBER
p0261	N71 17403	NO REPORT NUMBER
p0261	N71 17404	NO REPORT NUMBER
p0001	N71 17432	AGARD R 578 71
p0261	N71 18177	AGARD AH-32 71
p0001	N71 19353	AGARD CP 71 71
p0001	N71 19354	NO REPORT NUMBER
p0001	N71 19355	NO REPORT NUMBER
p0001	N71 19356	NO REPORT NUMBER
p0001	N71 19357	NASA TM X 66884
p0002	N71 19358	NO REPORT NUMBER
p0002	N71 19359	NO REPORT NUMBER
p0002	N71 19360	NO REPORT NUMBER
p0002	N71 19361	NASA TM X 66886
p0002	N71 19362	NO REPORT NUMBER
p0002	N71 19363	NO REPORT NUMBER
p0003	N71 19364	NO REPORT NUMBER
p0003	N71 19365	NO REPORT NUMBER
p0003	N71 19366	NASA TM X 66887
p0003	N71 19367	NO REPORT NUMBER
p0003	N71 19368	NASA TM X 66888
p0003	N71 19369	NO REPORT NUMBER
p0003	N71 19370	NO REPORT NUMBER
p0004	N71 19371	NASA TM X 66885
p0004	N71 19372	NO REPORT NUMBER
p0004	N71 19373	NO REPORT NUMBER
p0004	N71 19374	NO REPORT NUMBER
p0004	N71 19375	NO REPORT NUMBER
p0004	N71 19376	NO REPORT NUMBER
p0005	N71 19377	NO REPORT NUMBER
p0005	N71 19378	NO REPORT NUMBER
p0005	N71 19379	NO REPORT NUMBER
p0005	N71 19380	NO REPORT NUMBER
p0005	N71 19381	NO REPORT NUMBER
p0005	N71 19382	NO REPORT NUMBER
p0005	N71 19383	NO REPORT NUMBER
p0006	N71 19384	NO REPORT NUMBER
p0006	N71 19385	NO REPORT NUMBER
p0006	N71 19386	NO REPORT NUMBER
p0006	N71 19387	NO REPORT NUMBER
p0006	N71 19388	NO REPORT NUMBER
p0113	N71 19526	AGARD CP 78 71
p0113	N71 19527	NO REPORT NUMBER
p0113	N71 19528	NO REPORT NUMBER
p0113	N71 19529	NO REPORT NUMBER
p0113	N71 19530	NO REPORT NUMBER
p0113	N71 19531	NO REPORT NUMBER
p0113	N71 19532	NO REPORT NUMBER
p0189	N71 20002	AGARD R 582 71
p0205	N71 20027	AGARD AC 152 71
p0205	N71 20028	AGARDGRAPH 152
p0205	N71 20051	AGARD LS 43 71
p0205	N71 20052	NO REPORT NUMBER
p0205	N71 20053	NO REPORT NUMBER
p0205	N71 20054	NO REPORT NUMBER
p0205	N71 20055	NO REPORT NUMBER
p0205	N71 20056	NO REPORT NUMBER
p0206	N71 20057	NO REPORT NUMBER
p0206	N71 20058	NO REPORT NUMBER
p0206	N71 20059	NO REPORT NUMBER
p0206	N71 20060	NO REPORT NUMBER
p0206	N71 20061	NO REPORT NUMBER
p0206	N71 20062	NO REPORT NUMBER
p0206	N71 20063	NO REPORT NUMBER
p0207	N71 20064	NO REPORT NUMBER
p0207	N71 20065	NO REPORT NUMBER
p0207	N71 20066	NO REPORT NUMBER
p0207	N71 20067	NO REPORT NUMBER
p0207	N71 20068	NO REPORT NUMBER
p0207	N71 20069	NO REPORT NUMBER
p0207	N71 20070	NO REPORT NUMBER
p0207	N71 20071	AGARD AG 153 71
p0207	N71 20072	AGARDGRAPH 153
p0207	N71 20073	AGARD AG 149 71
p0207	N71 20074	AGARDGRAPH 149
p0207	N71 20075	NO REPORT NUMBER
p0207	N71 20076	NO REPORT NUMBER
p0207	N71 20077	NO REPORT NUMBER
p0207	N71 20078	NO REPORT NUMBER
p0207	N71 20079	NO REPORT NUMBER
p0207	N71 20080	NO REPORT NUMBER
p0207	N71 20081	NO REPORT NUMBER
p0207	N71 20082	NO REPORT NUMBER
p0207	N71 20083	NO REPORT NUMBER
p0207	N71 20084	NO REPORT NUMBER
p0207	N71 20085	NO REPORT NUMBER
p0207	N71 20086	NO REPORT NUMBER
p0207	N71 20087	NO REPORT NUMBER
p0207	N71 20088	NO REPORT NUMBER
p0207	N71 20089	NO REPORT NUMBER
p0207	N71 20090	NO REPORT NUMBER
p0207	N71 20091	NO REPORT NUMBER
p0207	N71 20092	NO REPORT NUMBER
p0207	N71 20093	NO REPORT NUMBER
p0207	N71 20094	NO REPORT NUMBER
p0207	N71 20095	NO REPORT NUMBER
p0207	N71 20096	NO REPORT NUMBER
p0207	N71 20097	NO REPORT NUMBER
p0207	N71 20098	NO REPORT NUMBER
p0207	N71 20099	NO REPORT NUMBER
p0207	N71 20100	NO REPORT NUMBER
p0207	N71 20101	NO REPORT NUMBER
p0207	N71 20102	NO REPORT NUMBER
p0207	N71 20103	NO REPORT NUMBER
p0207	N71 20104	NO REPORT NUMBER
p0207	N71 20105	NO REPORT NUMBER
p0207	N71 20106	NO REPORT NUMBER
p0207	N71 20107	NO REPORT NUMBER
p0207	N71 20108	NO REPORT NUMBER
p0207	N71 20109	NO REPORT NUMBER
p0207	N71 20110	NO REPORT NUMBER
p0207	N71 20111	NO REPORT NUMBER
p0207	N71 20112	NO REPORT NUMBER
p0207	N71 20113	NO REPORT NUMBER
p0207	N71 20114	NO REPORT NUMBER
p0207	N71 20115	NO REPORT NUMBER
p0207	N71 20116	NO REPORT NUMBER
p0207	N71 20117	NO REPORT NUMBER
p0207	N71 20118	NO REPORT NUMBER
p0207	N71 20119	NO REPORT NUMBER
p0207	N71 20120	NO REPORT NUMBER
p0207	N71 20121	NO REPORT NUMBER
p0207	N71 20122	NO REPORT NUMBER
p0207	N71 20123	NO REPORT NUMBER
p0207	N71 20124	NO REPORT NUMBER
p0207	N71 20125	NO REPORT NUMBER
p0207	N71 20126	NO REPORT NUMBER
p0207	N71 20127	NO REPORT NUMBER
p0207	N71 20128	NO REPORT NUMBER
p0207	N71 20129	NO REPORT NUMBER
p0207	N71 20130	NO REPORT NUMBER
p0207	N71 20131	NO REPORT NUMBER
p0207	N71 20132	NO REPORT NUMBER
p0207	N71 20133	NO REPORT NUMBER
p0207	N71 20134	NO REPORT NUMBER
p0207	N71 20135	NO REPORT NUMBER
p0207	N71 20136	NO REPORT NUMBER
p0207	N71 20137	NO REPORT NUMBER
p0207	N71 20138	NO REPORT NUMBER
p0207	N71 20139	NO REPORT NUMBER
p0207	N71 20140	NO REPORT NUMBER
p0207	N71 20141	NO REPORT NUMBER
p0207	N71 20142	NO REPORT NUMBER
p0207	N71 20143	NO REPORT NUMBER
p0207	N71 20144	NO REPORT NUMBER
p0207	N71 20145	NO REPORT NUMBER
p0207	N71 20146	NO REPORT NUMBER
p0207	N71 20147	NO REPORT NUMBER
p0207	N71 20148	NO REPORT NUMBER
p0207	N71 20149	NO REPORT NUMBER
p0207	N71 20150	NO REPORT NUMBER
p0207	N71 20151	NO REPORT NUMBER
p0207	N71 20152	NO REPORT NUMBER
p0207	N71 20153	NO REPORT NUMBER
p0207	N71 20154	NO REPORT NUMBER
p0207	N71 20155	NO REPORT NUMBER
p0207	N71 20156	NO REPORT NUMBER
p0207	N71 20157	NO REPORT NUMBER
p0207	N71 20158	NO REPORT NUMBER
p0207	N71 20159	NO REPORT NUMBER
p0207	N71 20160	NO REPORT NUMBER
p0207	N71 20161	NO REPORT NUMBER
p0207	N71 20162	NO REPORT NUMBER
p0207	N71 20163	NO REPORT NUMBER
p0207	N71 20164	NO REPORT NUMBER
p0207	N71 20165	NO REPORT NUMBER
p0207	N71 20166	NO REPORT NUMBER
p0207	N71 20167	NO REPORT NUMBER
p0207	N71 20168	NO REPORT NUMBER
p0207	N71 20169	NO REPORT NUMBER
p0207	N71 20170	NO REPORT NUMBER
p0207	N71 20171	NO REPORT NUMBER
p0207	N71 20172	NO REPORT NUMBER
p0207	N71 20173	NO REPORT NUMBER
p0207	N71 20174	NO REPORT NUMBER
p0207	N71 20175	NO REPORT NUMBER
p0207	N71 20176	NO REPORT NUMBER
p0207	N71 20177	NO REPORT NUMBER
p0207	N71 20178	NO REPORT NUMBER
p0207	N71 20179	NO REPORT NUMBER
p0207	N71 20180	NO REPORT NUMBER
p0207	N71 20181	NO REPORT NUMBER
p0207	N71 20182	NO REPORT NUMBER
p0207	N71 20183	NO REPORT NUMBER
p0207	N71 20184	NO REPORT NUMBER
p0207	N71 20185	NO REPORT NUMBER
p0207	N71 20186	NO REPORT NUMBER
p0207	N71 20187	NO REPORT NUMBER
p0207	N71 20188	NO REPORT NUMBER
p0207	N71 20189	NO REPORT NUMBER
p0207	N71 20190	NO REPORT NUMBER
p0207	N71 20191	NO REPORT NUMBER
p0207	N71 20192	NO REPORT NUMBER
p0207	N71 20193	NO REPORT NUMBER
p0207	N71 20194	NO REPORT NUMBER
p0207	N71 20195	NO REPORT NUMBER
p0207	N71 20196	NO REPORT NUMBER
p0207	N71 20197	NO REPORT NUMBER
p0207	N71 20198	NO REPORT NUMBER
p0207	N71 20199	NO REPORT NUMBER
p0207	N71 20200	NO REPORT NUMBER

p0088	N71 20359	AMRL TR 70 74
p0088	N71 20360	NO REPORT NUMBER
p0088	N71 20361	NO REPORT NUMBER
p0088	N71 20362	NO REPORT NUMBER
p0088	N71 20363	NO REPORT NUMBER
p0088	N71 20364	NO REPORT NUMBER
p0088	N71 20365	NO REPORT NUMBER
p0088	N71 20366	NO REPORT NUMBER
p0088	N71 20367	NO REPORT NUMBER
p0088	N71 20368	NO REPORT NUMBER
p0088	N71 20369	NO REPORT NUMBER
p0088	N71 20370	NO REPORT NUMBER
p0088	N71 20371	NASA TM X 66955
p0114	N71 21409	AGARD CP 70 71 PT 1
p0114	N71 21410	NO REPORT NUMBER
p0114	N71 21411	NO REPORT NUMBER
p0114	N71 21412	NO REPORT NUMBER
p0114	N71 21413	NO REPORT NUMBER
p0114	N71 21414	NO REPORT NUMBER
p0114	N71 21415	NO REPORT NUMBER
p0114	N71 21416	NO REPORT NUMBER
p0115	N71 21417	NO REPORT NUMBER
p0115	N71 21418	NO REPORT NUMBER
p0115	N71 21419	NO REPORT NUMBER
p0115	N71 21420	NO REPORT NUMBER
p0115	N71 21421	NO REPORT NUMBER
p0115	N71 21422	NO REPORT NUMBER
p0116	N71 21423	NO REPORT NUMBER
p0116	N71 21424	NO REPORT NUMBER
p0116	N71 21425	NO REPORT NUMBER
p0116	N71 21426	NO REPORT NUMBER
p0116	N71 21427	NO REPORT NUMBER
p0116	N71 21428	NO REPORT NUMBER
p0116	N71 21429	NO REPORT NUMBER
p0117	N71 21430	NO REPORT NUMBER
p0117	N71 21431	NO REPORT NUMBER
p0117	N71 21432	NO REPORT NUMBER
p0117	N71 21433	NO REPORT NUMBER
p0091	N71 22301	AGARD CP 81 71
p0091	N71 22302	NO REPORT NUMBER
p0091	N71 22303	NO REPORT NUMBER
p0091	N71 22304	NO REPORT NUMBER
p0091	N71 22305	NO REPORT NUMBER
p0091	N71 22306	NO REPORT NUMBER
p0091	N71 22307	NO REPORT NUMBER
p0091	N71 22308	NO REPORT NUMBER
p0092	N71 22309	NO REPORT NUMBER
p0092	N71 22310	NO REPORT NUMBER
p0092	N71 22311	NO REPORT NUMBER
p0092	N71 22312	NO REPORT NUMBER
p0092	N71 22313	NO REPORT NUMBER
p0092	N71 22314	NO REPORT NUMBER
p0093	N71 22315	NO REPORT NUMBER
p0093	N71 22316	NO REPORT NUMBER
p0093	N71 22317	NO REPORT NUMBER
p0093	N71 22318	NO REPORT NUMBER
p0093	N71 22319	NO REPORT NUMBER
p0093	N71 22320	NO REPORT NUMBER
p0094	N71 22321	NO REPORT NUMBER
p0281	N71 22699	AGARD AR 29 71
p0006	N71 23210	NASA TM X 67123
p0007	N71 23211	AGARD R 580 71
p0007	N71 23212	NO REPORT NUMBER
p0007	N71 23213	NO REPORT NUMBER
p0007	N71 23214	NO REPORT NUMBER
p0094	N71 23337	AGARD AG 150 71
p0094	N71 23338	AGARDGRAPH 150
p0094	N71 23339	NO REPORT NUMBER
p0094	N71 23340	NO REPORT NUMBER
p0094	N71 23341	NO REPORT NUMBER
p0095	N71 23342	NO REPORT NUMBER
p0095	N71 23343	NO REPORT NUMBER
p0095	N71 23344	NASA TM X 67138
p0027	N71 23410	AGARD CP 76 71
p0027	N71 23411	NO REPORT NUMBER
p0027	N71 23412	NO REPORT NUMBER
p0027	N71 23413	NO REPORT NUMBER
p0028	N71 23414	NO REPORT NUMBER
p0028	N71 23415	NO REPORT NUMBER
p0028	N71 23416	NO REPORT NUMBER
p0028	N71 23417	NO REPORT NUMBER
p0028	N71 23418	NASA TM X 67122
p0028	N71 23419	NO REPORT NUMBER
p0028	N71 23420	NO REPORT NUMBER
p0029	N71 23421	NO REPORT NUMBER
p0029	N71 23422	

# ACCESSION/REPORT NUMBER INDEX

p0030 N71 2148	NO REPORT NUMBER	p0152 N72 11183	NO REPORT NUMBER	10032 N72 11926	NO REPORT NUMBER
p0030 N71 2149	NO REPORT NUMBER	p0152 N72 11184	NO REPORT NUMBER	10032 N72 11927	NO REPORT NUMBER
p0030 N71 23430	NO REPORT NUMBER	p0152 N72 11185	NO REPORT NUMBER	10032 N72 11928	NO REPORT NUMBER
p0030 N71 23431	NO REPORT NUMBER	p0152 N72 11186	NO REPORT NUMBER	10032 N72 11929	NO REPORT NUMBER
p0117 N71 23451	AGARD CP 70 71	p0152 N72 11187	NO REPORT NUMBER	10033 N72 11930	NO REPORT NUMBER
p0117 N71 23452	NO REPORT NUMBER	p0152 N72 11188	NO REPORT NUMBER	10033 N72 11931	NO REPORT NUMBER
p0117 N71 23453	NO REPORT NUMBER	p0152 N72 11189	NO REPORT NUMBER	10033 N72 11932	NO REPORT NUMBER
p0118 N71 23454	NO REPORT NUMBER	p0151 N72 11190	NO REPORT NUMBER	10033 N72 11933	NO REPORT NUMBER
p0118 N71 23455	NO REPORT NUMBER	p0153 N72 11191	NO REPORT NUMBER	10033 N72 11934	NO REPORT NUMBER
p0118 N71 23456	NO REPORT NUMBER	p0153 N72 11192	NO REPORT NUMBER	10033 N72 11935	NO REPORT NUMBER
p0118 N71 23457	NO REPORT NUMBER	p0153 N72 11193	NO REPORT NUMBER	10034 N72 11936	NO REPORT NUMBER
p0118 N71 23458	NO REPORT NUMBER	p0153 N72 11194	NO REPORT NUMBER	10034 N72 11937	NO REPORT NUMBER
p0118 N71 23459	NO REPORT NUMBER	p0154 N72 11195	NO REPORT NUMBER	10034 N72 11938	NO REPORT NUMBER
p0119 N71 23460	NO REPORT NUMBER	p0154 N72 11196	NO REPORT NUMBER	10034 N72 11939	NO REPORT NUMBER
p0119 N71 23461	NO REPORT NUMBER	p0154 N72 11197	NO REPORT NUMBER	10172 N72 12162	AGARD AR 37 71
p0119 N71 23462	NO REPORT NUMBER	p0154 N72 11198	NO REPORT NUMBER	10206 N72 12492	AGARD CONE PROC 63
p0119 N71 23463	NO REPORT NUMBER	p0154 N72 11199	NO REPORT NUMBER		AGARD CP 63 71
p0119 N71 23464	NO REPORT NUMBER	p0154 N72 11200	NO REPORT NUMBER	p0207 N72 12493	NO REPORT NUMBER
p0119 N71 23465	NO REPORT NUMBER	p0154 N72 11201	NO REPORT NUMBER	p0207 N72 12494	NO REPORT NUMBER
p0119 N71 23466	NO REPORT NUMBER	p0154 N72 11202	NO REPORT NUMBER	p0207 N72 12495	NO REPORT NUMBER
p0119 N71 23467	NO REPORT NUMBER	p0154 N72 11203	NO REPORT NUMBER	p0207 N72 12496	NO REPORT NUMBER
p0120 N71 23468	NO REPORT NUMBER	p0155 N72 11204	NO REPORT NUMBER	p0207 N72 12497	NO REPORT NUMBER
p0120 N71 23469	NO REPORT NUMBER	p0155 N72 11205	NO REPORT NUMBER	p0207 N72 12498	NO REPORT NUMBER
p0120 N71 23470	NO REPORT NUMBER	p0155 N72 11206	NO REPORT NUMBER	p0207 N72 12499	NO REPORT NUMBER
p0120 N71 23471	NO REPORT NUMBER	p0217 N72 11511	AGARD R 586 71	p0207 N72 12500	NO REPORT NUMBER
p0120 N71 23472	NO REPORT NUMBER		UDC 551.551.5	p0208 N72 12501	NO REPORT NUMBER
p0120 N71 23473	NO REPORT NUMBER			p0208 N72 12502	NO REPORT NUMBER
p0121 N71 23474	NO REPORT NUMBER	p0251 N72 11668	AGARD CP 84 71	p0208 N72 12503	NO REPORT NUMBER
p0331 N71 23501	AGARD LS 44	p0251 N72 11669	NO REPORT NUMBER	p0208 N72 12504	NO REPORT NUMBER
p0331 N71 23502	NO REPORT NUMBER	p0251 N72 11670	NO REPORT NUMBER	p0208 N72 12505	NO REPORT NUMBER
p0331 N71 23503	NO REPORT NUMBER	p0251 N72 11671	NO REPORT NUMBER	p0208 N72 12506	NO REPORT NUMBER
p0331 N71 23504	NASA TM X 67142	p0251 N72 11672	NO REPORT NUMBER	p0208 N72 12507	NO REPORT NUMBER
p0331 N71 23505	NO REPORT NUMBER	p0251 N72 11673	NO REPORT NUMBER	p0209 N72 12508	NO REPORT NUMBER
p0331 N71 23506	NO REPORT NUMBER	p0251 N72 11674	NO REPORT NUMBER	p0277 N72 12861	AGARD LS 45 71
p0331 N71 23507	NO REPORT NUMBER	p0251 N72 11675	NO REPORT NUMBER	p0277 N72 12862	NO REPORT NUMBER
p0175 N71 25073	AGARD R 579 71	p0252 N72 11676	NO REPORT NUMBER	p0277 N72 12863	NASA TM X 6-384
p0303 N71 25080	AGARD AR 37 71	p0252 N72 11677	NO REPORT NUMBER	p0277 N72 12864	NO REPORT NUMBER
p0299 N71 25088	AGARD R 581 71	p0252 N72 11678	NO REPORT NUMBER	p0277 N72 12865	NO REPORT NUMBER
p0285 N71 25449	AGARD LS 46 71	p0252 N72 11679	NO REPORT NUMBER	p0277 N72 12866	NO REPORT NUMBER
p0261 N71 26951	NO REPORT NUMBER	p0252 N72 11680	NO REPORT NUMBER	p0278 N72 12867	NO REPORT NUMBER
p0262 N71 26952	NO REPORT NUMBER	p0252 N72 11681	NO REPORT NUMBER	p0278 N72 12868	NO REPORT NUMBER
p0262 N71 26953	NO REPORT NUMBER	p0252 N72 11682	NO REPORT NUMBER	p0278 N72 12869	NO REPORT NUMBER
p0262 N71 26954	NO REPORT NUMBER	p0252 N72 11683	NO REPORT NUMBER	p0278 N72 12870	NO REPORT NUMBER
p0262 N71 26955	NO REPORT NUMBER	p0253 N72 11684	NO REPORT NUMBER	p0299 N72 12950	AGARD AG 143 71
p0262 N71 26956	NO REPORT NUMBER	p0253 N72 11685	NO REPORT NUMBER		AGARDOGRAPH 148
p0262 N71 26957	NO REPORT NUMBER	p0253 N72 11686	NO REPORT NUMBER	p0016 N72 12978	AGARD R 583 71
p0262 N71 26958	NO REPORT NUMBER	p0253 N72 11687	NO REPORT NUMBER	p0285 N72 13882	AGARD AG 155 71
p0262 N71 26959	AGARD LS 47 71	p0253 N72 11688	NO REPORT NUMBER		AGARDOGRAPH 155
p0205 N71 27039	NO REPORT NUMBER	p0253 N72 11689	NO REPORT NUMBER	p0095 N72 14091	AGARD CP 83 71
p0205 N71 27040	NO REPORT NUMBER	p0253 N72 11690	NO REPORT NUMBER	p0095 N72 14092	NO REPORT NUMBER
p0205 N71 27041	NO REPORT NUMBER	p0253 N72 11691	NO REPORT NUMBER	p0095 N72 14093	NO REPORT NUMBER
p0205 N71 27042	NO REPORT NUMBER	p0254 N72 11692	NO REPORT NUMBER	p0095 N72 14094	NO REPORT NUMBER
p0206 N71 27073	NO REPORT NUMBER	p0254 N72 11693	NO REPORT NUMBER	p0095 N72 14095	NO REPORT NUMBER
p0206 N71 27044	NO REPORT NUMBER	p0254 N72 11694	NASA CR 122842	p0096 N72 14096	NO REPORT NUMBER
p0206 N71 27045	NO REPORT NUMBER	p0254 N72 11695	NO REPORT NUMBER	p0096 N72 14097	NO REPORT NUMBER
p0007 N71 29333	AGARD CP 80 71 PT 1	p0254 N72 11696	NO REPORT NUMBER	p0096 N72 14098	NO REPORT NUMBER
p0007 N71 29334	NO REPORT NUMBER	p0254 N72 11697	NO REPORT NUMBER	p0096 N72 14099	NO REPORT NUMBER
p0007 N71 29335	NO REPORT NUMBER	p0254 N72 11698	NO REPORT NUMBER	p0096 N72 14100	NO REPORT NUMBER
p0008 N71 29336	NO REPORT NUMBER	p0254 N72 11699	NO REPORT NUMBER	p0096 N72 14101	NO REPORT NUMBER
p0008 N71 29337	NO REPORT NUMBER	p0255 N72 11700	NO REPORT NUMBER	p0097 N72 14102	NO REPORT NUMBER
p0008 N71 29338	AGARD CP 80 71 PT 2	p0255 N72 11701	NO REPORT NUMBER	p0097 N72 14103	NO REPORT NUMBER
p0008 N71 29339	NO REPORT NUMBER	p0011 N72 11854	AGARD CP 83 71	p0097 N72 14104	NO REPORT NUMBER
p0008 N71 29340	NO REPORT NUMBER	p0011 N72 11855	NO REPORT NUMBER	p0097 N72 14105	NO REPORT NUMBER
p0009 N71 29341	NO REPORT NUMBER	p0011 N72 11856	NO REPORT NUMBER	p0097 N72 14106	NO REPORT NUMBER
p0009 N71 29342	NO REPORT NUMBER	p0011 N72 11857	NO REPORT NUMBER	p0097 N72 14107	NO REPORT NUMBER
p0009 N71 29343	NO REPORT NUMBER	p0011 N72 11858	NO REPORT NUMBER	p0097 N72 14108	NO REPORT NUMBER
p0009 N71 29344	NO REPORT NUMBER	p0012 N72 11859	NASA TM X 67412	p0098 N72 14109	NO REPORT NUMBER
p0009 N71 29345	NO REPORT NUMBER	p0012 N72 11860	NO REPORT NUMBER	p0098 N72 14110	NO REPORT NUMBER
p0009 N71 29346	NO REPORT NUMBER	p0012 N72 11861	NO REPORT NUMBER	p0098 N72 14111	NO REPORT NUMBER
p0009 N71 29347	NO REPORT NUMBER	p0012 N72 11862	NO REPORT NUMBER	p0098 N72 14112	NO REPORT NUMBER
p0010 N71 29348	NO REPORT NUMBER	p0012 N72 11863	NO REPORT NUMBER	p0175 N72 15269	
p0010 N71 29349	NO REPORT NUMBER	p0012 N72 11864	NO REPORT NUMBER		
p0010 N71 29350	NO REPORT NUMBER	p0012 N72 11865	NO REPORT NUMBER		
p0010 N71 31459	AGARD AR 34 71	p0013 N72 11866	NO REPORT NUMBER		
p0172 N71 34253	AGARD R 584 71	p0013 N72 11867	NO REPORT NUMBER		
	AGARD REPT 584	p0013 N72 11868	NO REPORT NUMBER		
p0010 N71 35198	AGARD R 583 71	p0013 N72 11869	NASA TM X 67413		
p0302 N71 36382	AGARD R 585 71	p0013 N72 11870	NASA TM X 67414		
p0010 N71 36490	AGARD AR 36 71	p0013 N72 11871	NO REPORT NUMBER		
p0011 N71 36492	NO REPORT NUMBER	p0014 N72 11872	NASA TM X 67415		
p0011 N71 36493	NO REPORT NUMBER	p0014 N72 11873	NO REPORT NUMBER		
p0189 N71 36776	AGARD LS 47 71	p0014 N72 11874	NO REPORT NUMBER		
p0189 N71 36777	NO REPORT NUMBER	p0014 N72 11875	NO REPORT NUMBER		
p0189 N71 36778	NO REPORT NUMBER	p0014 N72 11876	NO REPORT NUMBER		
p0189 N71 36779	NO REPORT NUMBER	p0014 N72 11877	NO REPORT NUMBER		
p0189 N71 36780	NO REPORT NUMBER	p0015 N72 11878	NASA TM X 67416		
p0190 N71 36781	NO REPORT NUMBER	p0015 N72 11879	NASA TM X 67417		
p0190 N71 36782	NO REPORT NUMBER	p0015 N72 11880	NASA TM X 67418		
p0190 N71 36783	NO REPORT NUMBER	p0015 N72 11881	NO REPORT NUMBER		
p0190 N71 36784	NO REPORT NUMBER	p0015 N72 11882	NASA TM X 67419		
p0190 N71 36785	NO REPORT NUMBER	p0016 N72 11883	NO REPORT NUMBER		
p0190 N71 36786	NO REPORT NUMBER	p0016 N72 11884	NO REPORT NUMBER		
p0190 N71 36787	NO REPORT NUMBER	p0016 N72 11885	NO REPORT NUMBER		
p0190 N71 36788	NO REPORT NUMBER	p0016 N72 11886	NO REPORT NUMBER		
p0190 N71 36789	NO REPORT NUMBER	p0016 N72 11887	AGARD CP 88 71		
p0190 N71 36790	SC DR 710194	p0016 N72 11888	NO REPORT NUMBER		
p0151 N72 11174	AGARD CP 94 71	p0016 N72 11889	NO REPORT NUMBER		
p0151 N72 11175	NO REPORT NUMBER	p0016 N72 11890	NO REPORT NUMBER		
p0151 N72 11176	NO REPORT NUMBER	p0016 N72 11891	NO REPORT NUMBER		
p0151 N72 11177	NO REPORT NUMBER	p0016 N72 11892	NO REPORT NUMBER		
p0151 N72 11178	NO REPORT NUMBER	p0016 N72 11893	NO REPORT NUMBER		
p0151 N72 11179	NO REPORT NUMBER	p0016 N72 11894	NO REPORT NUMBER		
p0151 N72 11180	NO REPORT NUMBER	p0016 N72 11895	NO REPORT NUMBER		
p0151 N72 11181	NO REPORT NUMBER	p0017 N72 11924	NO REPORT NUMBER		
p0152 N72 11182	NO REPORT NUMBER	p0017 N72 11925	NO REPORT NUMBER		

## ACCESSION/REPORT NUMBER INDEX

p0125 N72 18115	NO REPORT NUMBER	p0192 N72 19489	NO REPORT NUMBER	p0130 N72 21149	NO REPORT NUMBER
p0125 N72 18116	NO REPORT NUMBER	p0192 N72 19500	NO REPORT NUMBER	p0130 N72 21150	NO REPORT NUMBER
p0125 N72 18117	NASA CR 125452	p0192 N72 19501	NO REPORT NUMBER	p0130 N72 21151	NO REPORT NUMBER
p0125 N72 18118	NO REPORT NUMBER	p0193 N72 19502	NO REPORT NUMBER	p0130 N72 21152	NO REPORT NUMBER
p0126 N72 18119	NO REPORT NUMBER	p0193 N72 19503	NO REPORT NUMBER	p0130 N72 21153	NO REPORT NUMBER
p0203 N72 18685	AGARD CP 91 71	p0193 N72 19504	NO REPORT NUMBER	p0155 N72 21211	AGARD AG 158
	UDC 533 687	p0193 N72 19505	NO REPORT NUMBER		AGARDOGRAPH 158
p0263 N72 18686	NO REPORT NUMBER	p0193 N72 19506	NO REPORT NUMBER	p0155 N72 21212	NO REPORT NUMBER
p0263 N72 18687	NO REPORT NUMBER	p0193 N72 19507	NO REPORT NUMBER	p0155 N72 21213	NO REPORT NUMBER
p0263 N72 18688	NO REPORT NUMBER	p0194 N72 19508	NO REPORT NUMBER	p0155 N72 21214	NO REPORT NUMBER
p0263 N72 18689	NO REPORT NUMBER	p0194 N72 19509	NO REPORT NUMBER	p0155 N72 21215	NO REPORT NUMBER
p0263 N72 18690	NO REPORT NUMBER	p0194 N72 19510	NO REPORT NUMBER	p0156 N72 21216	NO REPORT NUMBER
p0263 N72 18691	NO REPORT NUMBER	p0194 N72 19511	NO REPORT NUMBER	p0156 N72 21217	NO REPORT NUMBER
p0263 N72 18692	NASA TM X 67494	p0194 N72 19512	NO REPORT NUMBER	p0156 N72 21218	NO REPORT NUMBER
p0264 N72 18693	NO REPORT NUMBER	p0194 N72 19513	NO REPORT NUMBER	p0158 N72 21219	NO REPORT NUMBER
p0264 N72 18694	NO REPORT NUMBER	p0194 N72 19514	NO REPORT NUMBER	p0158 N72 21220	NO REPORT NUMBER
p0264 N72 18695	NO REPORT NUMBER	p0197 N72 19541	AGARD R 587 71	p0158 N72 21221	NO REPORT NUMBER
p0264 N72 18696	NO REPORT NUMBER	p0197 N72 19542	NO REPORT NUMBER	p0158 N72 21222	NO REPORT NUMBER
p0264 N72 18697	NO REPORT NUMBER	p0197 N72 19543	NO REPORT NUMBER	p0158 N72 21223	NO REPORT NUMBER
p0264 N72 18698	NO REPORT NUMBER	p0175 N72 20273	AGARD CP 93	p0158 N72 21224	NO REPORT NUMBER
p0264 N72 18699	NASA CR 125513	p0175 N72 20274	NO REPORT NUMBER	p0158 N72 21225	NO REPORT NUMBER
p0265 N72 18699	NO REPORT NUMBER	p0175 N72 20275	NO REPORT NUMBER	p0157 N72 21226	NO REPORT NUMBER
p0265 N72 18700	NO REPORT NUMBER	p0175 N72 20276	NO REPORT NUMBER	p0157 N72 21227	NO REPORT NUMBER
p0265 N72 18701	NO REPORT NUMBER	p0175 N72 20277	NO REPORT NUMBER	p0157 N72 21228	NO REPORT NUMBER
p0265 N72 18702	NO REPORT NUMBER	p0176 N72 20278	NO REPORT NUMBER	p0157 N72 21229	NO REPORT NUMBER
p0265 N72 18703	NO REPORT NUMBER	p0176 N72 20279	NO REPORT NUMBER	p0217 N72 21590	AGARD AR 40
p0265 N72 18704	NO REPORT NUMBER	p0176 N72 20280	NO REPORT NUMBER	p0217 N72 21591	AGARD AR 40
p0265 N72 18705	NO REPORT NUMBER	p0176 N72 20281	NASA CR 125903		NASA TM X 67491
p0266 N72 18706	NO REPORT NUMBER	p0176 N72 20282	NO REPORT NUMBER	p0285 N72 21900	AGARD CP 98
p0266 N72 18707	NO REPORT NUMBER	p0176 N72 20283	NO REPORT NUMBER	p0285 N72 21901	NO REPORT NUMBER
p0266 N72 18708	NO REPORT NUMBER	p0177 N72 20284	NO REPORT NUMBER	p0285 N72 21902	NO REPORT NUMBER
p0266 N72 18709	NASA TM X 67495	p0177 N72 20285	NO REPORT NUMBER	p0285 N72 21903	NO REPORT NUMBER
p0266 N72 18710	NO REPORT NUMBER	p0177 N72 20286	NASA CR 125904	p0285 N72 21904	NO REPORT NUMBER
p0266 N72 18711	NO REPORT NUMBER	p0177 N72 20287	NO REPORT NUMBER	p0286 N72 21905	NASA TM X 68303
p0266 N72 18712	NO REPORT NUMBER	p0177 N72 20288	NO REPORT NUMBER	p0286 N72 21906	NO REPORT NUMBER
p0267 N72 18713	NO REPORT NUMBER	p0177 N72 20289	NO REPORT NUMBER	p0286 N72 21907	NO REPORT NUMBER
p0267 N72 18714	NO REPORT NUMBER	p0178 N72 20290	NO REPORT NUMBER	p0286 N72 21908	NO REPORT NUMBER
p0267 N72 18715	NO REPORT NUMBER	p0178 N72 20291	NO REPORT NUMBER	p0286 N72 21909	NO REPORT NUMBER
p0267 N72 18716	NO REPORT NUMBER	p0178 N72 20292	NO REPORT NUMBER	p0286 N72 21910	NO REPORT NUMBER
p0267 N72 18717	NO REPORT NUMBER	p0178 N72 20293	NO REPORT NUMBER	p0287 N72 21911	NO REPORT NUMBER
p0267 N72 18718	NO REPORT NUMBER	p0178 N72 20294	NO REPORT NUMBER	p0287 N72 21912	NO REPORT NUMBER
p0267 N72 18719	AGARD LS 57	p0178 N72 20295	NO REPORT NUMBER	p0287 N72 21913	NO REPORT NUMBER
p0269 N72 18946	NO REPORT NUMBER	p0178 N72 20296	NO REPORT NUMBER	p0287 N72 21914	NO REPORT NUMBER
p0269 N72 18947	NO REPORT NUMBER	p0179 N72 20297	NO REPORT NUMBER	p0287 N72 21915	NO REPORT NUMBER
p0269 N72 18948	NO REPORT NUMBER	p0179 N72 20298	NO REPORT NUMBER	p0287 N72 21916	NO REPORT NUMBER
p0269 N72 18949	NO REPORT NUMBER	p0179 N72 20299	NO REPORT NUMBER	p0287 N72 21917	NO REPORT NUMBER
p0269 N72 18950	AGARD CP 88 71	p0179 N72 20300	NO REPORT NUMBER	p0288 N72 21918	NO REPORT NUMBER



## ACCESSION/REPORT NUMBER INDEX

00072 N72 25037	NO REPORT NUMBER	00038 N72 32017	AGARD CP 106	00139 N73 14167	NO REPORT NUMBER
00072 N72 25038	AMRL T. 71 58	00038 N72 32018	NO REPORT NUMBER	00140 N73 14168	NO REPORT NUMBER
00072 N72 25039	NO REPORT NUMBER	00038 N72 32019	NO REPORT NUMBER	00140 N73 14169	NO REPORT NUMBER
00072 N72 25040	AMRL TP 7 59	00038 N72 32020	NO REPORT NUMBER	00140 N73 14170	NO REPORT NUMBER
00072 N72 25041	NO REPORT NUMBER	00038 N72 32021	NO REPORT NUMBER	00290 N73 14898	AGARD AG 162 PT 2
00072 N72 25042	NO REPORT NUMBER	00038 N72 32022	NO REPORT NUMBER	00041 N73 14998	AGARDGRAPH 162 PT 2
00072 N72 25043	NO REPORT NUMBER	00038 N72 32023	NO REPORT NUMBER	00041 N73 14999	AGARD CP 102
00072 N72 25044	NO REPORT NUMBER	00039 N72 32024	NO REPORT NUMBER	00041 N73 15000	NO REPORT NUMBER
00073 N72 25045	NO REPORT NUMBER	00039 N72 32025	NO REPORT NUMBER	00041 N73 15001	NO REPORT NUMBER
00073 N72 25046	NO REPORT NUMBER	00039 N72 32026	NO REPORT NUMBER	00041 N73 15002	NO REPORT NUMBER
00073 N72 25047	AGARD CP 95 FT 2	00039 N72 32027	NO REPORT NUMBER	00041 N73 15003	NO REPORT NUMBER
00073 N72 25048	NO REPORT NUMBER	00039 N72 32028	NO REPORT NUMBER	00042 N73 15004	NO REPORT NUMBER
00073 N72 25049	NO REPORT NUMBER	00039 N72 32029	NO REPORT NUMBER	00042 N73 15005	NO REPORT NUMBER
00073 N72 25050	NO REPORT NUMBER	00039 N72 32030	NO REPORT NUMBER	00042 N73 15006	NO REPORT NUMBER
00073 N72 25051	NO REPORT NUMBER	00039 N72 32031	NO REPORT NUMBER	00042 N73 15007	NO REPORT NUMBER
00074 N72 25052	NO REPORT NUMBER	00040 N72 32032	NO REPORT NUMBER	00042 N73 15008	NO REPORT NUMBER
00074 N72 25053	NO REPORT NUMBER	00040 N72 32033	NO REPORT NUMBER	00042 N73 15009	NO REPORT NUMBER
00074 N72 25054	NO REPORT NUMBER	00040 N72 32034	NO REPORT NUMBER	00042 N73 15010	NO REPORT NUMBER
00074 N72 25055	NO REPORT NUMBER	00040 N72 32035	NO REPORT NUMBER	00042 N73 15011	NO REPORT NUMBER
00074 N72 25056	NASA TM X 68370	00040 N72 32036	NO REPORT NUMBER	00042 N73 15012	NO REPORT NUMBER
00074 N72 25057	NO REPORT NUMBER	00040 N72 32037	NO REPORT NUMBER	00043 N73 15013	NO REPORT NUMBER
00074 N72 25058	NO REPORT NUMBER	00040 N72 32038	NO REPORT NUMBER	00043 N73 15014	NO REPORT NUMBER
00074 N72 25059	NO REPORT NUMBER	00195 N72 32457	AGARD AP 39	00043 N73 15015	NO REPORT NUMBER
00075 N72 25060	AGARD AG 159	00182 N72 32267	AGARD R 598	00043 N73 15016	NO REPORT NUMBER
00187 N72 25346	AGARDGRAPH 159	00290 N72 33915	AGARD R 597	00043 N73 15017	NO REPORT NUMBER
00194 N72 25419	AGARD AP 43	00133 N73 10187	AGARD CP 103	00043 N73 15018	NO REPORT NUMBER
00194 N72 25420	AGARD AG 160 VOL 3	00131 N73 10188	NO REPORT NUMBER	00043 N73 15019	NO REPORT NUMBER
00199 N72 25493	AGARDGRAPH 160 VOL 3	00131 N73 10189	NO REPORT NUMBER	00043 N73 15020	NO REPORT NUMBER
00199 N72 25494	AGARD LS 49	00131 N73 10190	NO REPORT NUMBER	00302 N73 15968	NO REPORT NUMBER
00199 N72 25495	NO REPORT NUMBER	00131 N73 10191	NO REPORT NUMBER	00291 N73 16896	AGARD CP 118
00199 N72 25496	NO REPORT NUMBER	00131 N73 10192	NO REPORT NUMBER	00291 N73 16897	NO REPORT NUMBER
00199 N72 25497	NO REPORT NUMBER	00131 N73 10193	NO REPORT NUMBER	00291 N73 16898	NO REPORT NUMBER
00199 N72 25498	NO REPORT NUMBER	00131 N73 10194	NO REPORT NUMBER	00291 N73 16899	NO REPORT NUMBER
00199 N72 25499	NO REPORT NUMBER	00131 N73 10195	NO REPORT NUMBER	00291 N73 16900	NO REPORT NUMBER
00199 N72 25500	NO REPORT NUMBER	00132 N73 10196	NO REPORT NUMBER	00291 N73 16901	NO REPORT NUMBER
00199 N72 25501	NASA CR 126767	00132 N73 10197	NO REPORT NUMBER	00291 N73 16902	NO REPORT NUMBER
00200 N72 25502	NO REPORT NUMBER	00132 N73 10198	NO REPORT NUMBER	00291 N73 16903	NO REPORT NUMBER
00200 N72 25503	NO REPORT NUMBER	00132 N73 10199	NO REPORT NUMBER	00291 N73 16904	NO REPORT NUMBER
00200 N72 25504	NO REPORT NUMBER	00132 N73 10200	NO REPORT NUMBER	00043 N72 16989	AGARD CP 119
00200 N72 25505	NO REPORT NUMBER	00132 N73 10201	NO REPORT NUMBER	00044 N73 16990	NO REPORT NUMBER
00200 N72 25506	NO REPORT NUMBER	00132 N73 10202	NO REPORT NUMBER	00044 N73 16991	NO REPORT NUMBER
00200 N72 25507	AGARD CP 95 FT 3	00133 N73 10203	NO REPORT NUMBER	00044 N73 16992	NO REPORT NUMBER
00200 N72 25508	NO REPORT NUMBER	00133 N73 10204	NO REPORT NUMBER	00044 N73 16993	NO REPORT NUMBER
00200 N72 25509	NO REPORT NUMBER	00133 N73 10205	NO REPORT NUMBER	00044 N73 16994	NO REPORT NUMBER
00200 N72 25510	NO REPORT NUMBER	00133 N73 10206	NO REPORT NUMBER	00044 N73 16995	NO REPORT NUMBER
00200 N72 25511	NO REPORT NUMBER	00133 N73 10207	NO REPORT NUMBER	00044 N7	

## ACCESSION; REPORT NUMBER INDEX

p0065 N73 19051	NO REPORT NUMBER	p0231 N73 20710	NO REPORT NUMBER	p0017 N73 22953	NO REPORT NUMBER
p0066 N73 19052	NO REPORT NUMBER	p0231 N73 20711	NO REPORT NUMBER	p0017 N73 22954	NO REPORT NUMBER
p0066 N73 19053	NO REPORT NUMBER	p0231 N73 20712	NO REPORT NUMBER	p0018 N73 22955	NO REPORT NUMBER
p0066 N73 19054	NO REPORT NUMBER	p0231 N73 20713	NO REPORT NUMBER	p0018 N73 22956	NO REPORT NUMBER
p0066 N73 19055	NO REPORT NUMBER	p0231 N73 20714	NO REPORT NUMBER	p0018 N73 22957	NO REPORT NUMBER
p0066 N73 19056	NO REPORT NUMBER	p0231 N73 20715	NO REPORT NUMBER	p0018 N73 22958	NO REPORT NUMBER
p0066 N73 19057	NO REPORT NUMBER	p0232 N73 20716	NO REPORT NUMBER	p0018 N73 22959	NO REPORT NUMBER
p0077 N73 19065	AGARD CP 99	p0232 N73 20717	NO REPORT NUMBER	p0083 N73 23057	AGARD CP 110
p0077 N73 19066	NO REPORT NUMBER	p0300 N73 20945	AGARD CP 165	p0083 N73 23058	NO REPORT NUMBER
p0077 N73 19067	NO REPORT NUMBER		AGARD GRAPH 165	p0083 N73 23059	NO REPORT NUMBER
p0077 N73 19068	NO REPORT NUMBER	p0304 N73 20959	NO REPORT NUMBER	p0083 N73 23060	NO REPORT NUMBER
p0077 N73 19069	NO REPORT NUMBER	p0046 N73 21008	AGARD CP 121	p0083 N73 23061	NO REPORT NUMBER
p0077 N73 19070	NO REPORT NUMBER	p0046 N73 21009	NO REPORT NUMBER	p0083 N73 23062	NO REPORT NUMBER
p0077 N73 19071	NO REPORT NUMBER	p0046 N73 21010	NO REPORT NUMBER	p0083 N73 23063	NO REPORT NUMBER
p0077 N73 19072	NO REPORT NUMBER	p0046 N73 21011	NO REPORT NUMBER	p0083 N73 23064	NO REPORT NUMBER
p0078 N73 19073	NO REPORT NUMBER	p0047 N73 21012	NO REPORT NUMBER	p0083 N73 23065	NO REPORT NUMBER
p0078 N73 19074	NO REPORT NUMBER	p0047 N73 21013	NO REPORT NUMBER	p0084 N73 23066	NO REPORT NUMBER
p0078 N73 19075	NO REPORT NUMBER	p0047 N73 21014	NO REPORT NUMBER	p0084 N73 23067	NO REPORT NUMBER
p0078 N73 19076	AMRL TR 71 116	p0047 N73 21015	NO REPORT NUMBER	p0084 N73 23068	NO REPORT NUMBER
p0104 N73 19143	AGARD CP 101	p0047 N73 21016	NO REPORT NUMBER	p0140 N73 23108	AGARD AH 53
p0104 N73 19144	NO REPORT NUMBER	p0047 N73 21017	NO REPORT NUMBER	p0201 N73 23597	AGARD CP 120
p0105 N73 19145	NO REPORT NUMBER	p0047 N73 21018	NO REPORT NUMBER	p0201 N73 23598	NO REPORT NUMBER
p0105 N73 19146	AMRL TR 71 113	p0047 N73 21019	NO REPORT NUMBER	p0201 N73 23599	NO REPORT NUMBER
p0105 N73 19147	AMRL TR 71 115	p0048 N73 21020	NO REPORT NUMBER	p0201 N73 23600	NO REPORT NUMBER
p0105 N73 19148	NO REPORT NUMBER	p0048 N73 21021	NO REPORT NUMBER	p0201 N73 23601	NO REPORT NUMBER
p0105 N73 19149	NO REPORT NUMBER	p0048 N73 21022	NO REPORT NUMBER	p0201 N73 23602	NO REPORT NUMBER
p0105 N73 19150	NO REPORT NUMBER	p0048 N73 21023	NO REPORT NUMBER	p0201 N73 23603	NO REPORT NUMBER
p0106 N73 19151	NO REPORT NUMBER	p0048 N73 21024	NO REPORT NUMBER	p0201 N73 23604	NO REPORT NUMBER
p0106 N73 19152	NO REPORT NUMBER	p0048 N73 21025	NO REPORT NUMBER	p0201 N73 23605	NO REPORT NUMBER
p0106 N73 19153	NO REPORT NUMBER	p0048 N73 21026	NO REPORT NUMBER	p0202 N73 23606	NO REPORT NUMBER
p0106 N73 19154	AMRL TR 72 3	p0048 N73 21027	NO REPORT NUMBER	p0202 N73 23607	NO REPORT NUMBER
p0106 N73 19155	NO REPORT NUMBER	p0048 N73 21028	NO REPORT NUMBER	p0202 N73 23608	NO REPORT NUMBER
p0106 N73 19156	NO REPORT NUMBER	p0048 N73 21029	NO REPORT NUMBER	p0202 N73 23609	NO REPORT NUMBER
p0268 N73 19794	AGARD AG 164	p0049 N73 21030	AGARD CP 111	p0202 N73 23610	NO REPORT NUMBER
	AGARDGRAPH 164	p0049 N73 21031	NO REPORT NUMBER	p0203 N73 23611	NO REPORT NUMBER
p0268 N73 19795	NO REPORT NUMBER	p0049 N73 21032	NO REPORT NUMBER	p0203 N73 23612	NO REPORT NUMBER
p0268 N73 19796	NO REPORT NUMBER	p0049 N73 21033	NO REPORT NUMBER	p0203 N73 23613	NO REPORT NUMBER
p0268 N73 19797	NO REPORT NUMBER	p0049 N73 21034	NO REPORT NUMBER	p0203 N73 23614	NO REPORT NUMBER
p0268 N73 19798	NO REPORT NUMBER	p0049 N73 21035	NO REPORT NUMBER	p0203 N73 23615	NO REPORT NUMBER
p0268 N73 19799	NO REPORT NUMBER	p0049 N73 21036	NO REPORT NUMBER	p0203 N73 23616	NO REPORT NUMBER
p0268 N73 19800	NO REPORT NUMBER	p0049 N73 21037	NO REPORT NUMBER	p0203 N73 23617	NO REPORT NUMBER
p0269 N73 19801	NO REPORT NUMBER	p0050 N73 21038	NO REPORT NUMBER	p0203 N73 23618	NO REPORT NUMBER
p0269 N73 19802	NO REPORT NUMBER	p0050 N73 21039	NO REPORT NUMBER	p0232 N73 23689	AGARD CP 105
p0269 N73 19803	NO REPORT NUMBER	p0050 N73 21040	NO REPORT NUMBER	p0232 N73 23690	NO REPORT NUMBER
p0269 N73 19804	NO REPORT NUMBER	p0050 N73 21041	NO REPORT NUMBER	p0232 N73 23691	NO REPORT NUMBER
p0269 N73 19805	NO REPORT NUMBER	p0050 N73 21042	NO REPORT NUMBER	p0232 N73 23692	NO REPORT NUMBER
p0269 N73 19806	NO REPORT NUMBER	p0050 N73 21043	NO REPORT NUMBER	p0232 N73 23693	NO REPORT NUMBER
p0269 N73 19807	NO REPORT NUMBER	p0050 N73 21044	NO REPORT NUMBER	p0232 N73 23694	NO REPORT NUMBER
p0270 N73 1					

## ACCESSION/REPORT NUMBER INDEX

p0053 N73 24047	NO REPORT NUMBER	p0055 N73 27908	AGARD R 577 PT 2	p0086 N74 13794	NO REPORT NUMBER
p0053 N73 24048	NO REPORT NUMBER	p0292 N73 28884	AGARD AR 54	p0086 N74 13795	NO REPORT NUMBER
p0053 N73 24049	NO REPORT NUMBER	p0292 N73 29905	AGARD CP 113	p0086 N74 13796	NO REPORT NUMBER
p0053 N73 24050	NO REPORT NUMBER	p0292 N73 29906	NO REPORT NUMBER	p0086 N74 13797	NO REPORT NUMBER
p0053 N73 24051	NO REPORT NUMBER	p0292 N73 29907	NO REPORT NUMBER	p0086 N74 13798	NO REPORT NUMBER
p0053 N73 24052	NO REPORT NUMBER	p0292 N73 29908	NO REPORT NUMBER	p0086 N74 13799	NO REPORT NUMBER
p0053 N73 24053	NO REPORT NUMBER	p0292 N73 29909	NO REPORT NUMBER	p0086 N74 13800	NO REPORT NUMBER
p0054 N73 24054	NO REPORT NUMBER	p0292 N73 29910	NO REPORT NUMBER	p0087 N74 13801	NO REPORT NUMBER
p0158 N73 24201	AGARD CP 117	p0293 N73 29911	NO REPORT NUMBER	p0087 N74 13802	NO REPORT NUMBER
p0158 N73 24202	NO REPORT NUMBER	p0293 N73 29912	NO REPORT NUMBER	p0087 N74 13803	NO REPORT NUMBER
p0158 N73 24203	NO REPORT NUMBER	p0293 N73 29913	NO REPORT NUMBER	p0087 N74 13804	NO REPORT NUMBER
p0158 N73 24204	NO REPORT NUMBER	p0293 N73 29914	NO REPORT NUMBER	p0087 N74 13805	NO REPORT NUMBER
p0158 N73 24205	NO REPORT NUMBER	p0293 N73 29915	NO REPORT NUMBER	p0087 N74 13806	NO REPORT NUMBER
p0159 N73 24206	NO REPORT NUMBER	p0293 N73 29916	NO REPORT NUMBER	p0145 N74 13846	AGARD CP 127
p0159 N73 24207	NO REPORT NUMBER	p0293 N73 29917	NO REPORT NUMBER	p0145 N74 13847	NO REPORT NUMBER
p0159 N73 24208	NO REPORT NUMBER	p0293 N73 29918	NO REPORT NUMBER	p0145 N74 13848	NO REPORT NUMBER
p0159 N73 24209	NO REPORT NUMBER	p0293 N73 29919	NO REPORT NUMBER	p0145 N74 13849	NO REPORT NUMBER
p0159 N73 24210	NO REPORT NUMBER	p0294 N73 29920	NO REPORT NUMBER	p0145 N74 13850	NO REPORT NUMBER
p0159 N73 24211	NO REPORT NUMBER	p0294 N73 29921	NO REPORT NUMBER	p0146 N74 13851	NO REPORT NUMBER
p0159 N73 24212	NO REPORT NUMBER	p0294 N73 29922	NO REPORT NUMBER	p0146 N74 13852	NO REPORT NUMBER
p0271 N73 24798	NO REPORT NUMBER	p0294 N73 29923	NO REPORT NUMBER	p0146 N74 13853	NO REPORT NUMBER
p0300 N73 25986	AGARD R 606	p0294 N73 29924	AGARD LS 62	p0146 N74 13854	NO REPORT NUMBER
p0140 N73 26121	AGARD CP 107	p0294 N73 29925	AGARD LS 62	p0147 N74 13855	NO REPORT NUMBER
p0140 N73 26122	NO REPORT NUMBER	p0294 N73 29926	NO REPORT NUMBER	p0147 N74 13856	NO REPORT NUMBER
p0140 N73 26123	NO REPORT NUMBER	p0294 N73 29927	NO REPORT NUMBER	p0147 N74 13857	NO REPORT NUMBER
p0140 N73 26124	NO REPORT NUMBER	p0294 N73 29928	NO REPORT NUMBER	p0147 N74 13858	NO REPORT NUMBER
p0141 N73 26125	NO REPORT NUMBER	p0295 N73 29929	NO REPORT NUMBER	p0147 N74 13859	NO REPORT NUMBER
p0141 N73 26126	NO REPORT NUMBER	p0295 N73 29930	NO REPORT NUMBER	p0147 N74 13860	NO REPORT NUMBER
p0141 N73 26127	NO REPORT NUMBER	p0295 N73 29931	NO REPORT NUMBER	p0147 N74 13861	NO REPORT NUMBER
p0141 N73 26128	NO REPORT NUMBER	p0295 N73 29932	NO REPORT NUMBER	p0147 N74 13862	NO REPORT NUMBER
p0141 N73 26129	NO REPORT NUMBER	p0295 N73 29933	NO REPORT NUMBER	p0147 N74 13863	NO REPORT NUMBER
p0141 N73 26130	NO REPORT NUMBER	p0295 N73 29934	NO REPORT NUMBER	p0148 N74 13864	NO REPORT NUMBER
p0141 N73 26131	NO REPORT NUMBER	p0111 N73 31830	AGARD AG 169	p0148 N74 13865	NO REPORT NUMBER
p0141 N73 26132	NO REPORT NUMBER		AGARDOGRAPH 168	p0148 N74 13866	NO REPORT NUMBER
p0141 N73 26133	NO REPORT NUMBER	p0055 N73 31954	AGARD AR 62	p0148 N74 13867	NO REPORT NUMBER
p0142 N73 26134	NO REPORT NUMBER	p0143 N73 32053	AGARD LS 58	p0148 N74 13868	NO REPORT NUMBER
p0142 N73 26135	NO REPORT NUMBER	p0143 N73 32054	NO REPORT NUMBER	p0148 N74 13869	NO REPORT NUMBER
p0142 N73 26136	NO REPORT NUMBER	p0143 N73 32055	NO REPORT NUMBER	p0149 N74 13870	NO REPORT NUMBER
p0142 N73 26137	NO REPORT NUMBER	p0143 N73 32056	NO REPORT NUMBER	p0149 N74 13871	NO REPORT NUMBER
p0142 N73 26138	NO REPORT NUMBER	p0143 N73 32057	NO REPORT NUMBER	p0185 N74 13906	AGARD CP 130
p0142 N73 26139	NO REPORT NUMBER	p0143 N73 32058	NO REPORT NUMBER	p0185 N74 13907	NO REPORT NUMBER
p0142 N73 26140	NO REPORT NUMBER	p0241 N73 33619	AGARD LS 61	p0185 N74 13908	NO REPORT NUMBER
p0142 N73 26141	NO REPORT NUMBER	p0241 N73 33620	NO REPORT NUMBER	p0185 N74 13909	NO REPORT NUMBER
p0142 N73 26142	NO REPORT NUMBER	p0241 N73 33621	NO REPORT NUMBER	p0185 N74 13910	NO REPORT NUMBER
p0172 N73 26239	AGARD R 601	p0241 N73 33622	NO REPORT NUMBER	p0185 N74 13911	NO REPORT NUMBER
p0173 N73 26240	NO REPORT NUMBER	p0241 N73 33623	NO REPORT NUMBER	p0185 N74 13912	NO REPORT NUMBER
p0173 N73 26241	NO REPORT NUMBER	p0241 N73 33624	NO REPORT NUMBER	p0185 N74 13913	NO REPORT NUMBER
p0173 N73 26242	NO REPORT NUMBER	p0241 N73 33625	NO REPORT NUMBER	p0185 N74 13914	NO REPORT NUMBER
p0173 N					

# ACCESSION REPORT NUMBER INDEX

p0220 N74 14296	NO REPORT NUMBER	p0058 N74 17726	NO REPORT NUMBER	p0185 N74 22920	NO REPORT NUMBER
p0220 N74 14297	NO REPORT NUMBER	p0058 N74 17727	NO REPORT NUMBER	p0185 N74 22921	NO REPORT NUMBER
p0220 N74 14298	NO REPORT NUMBER	p0058 N74 17728	AGARD R 608	p0204 N74 23108	AGARD R 610
p0221 N74 14299	NO REPORT NUMBER	p0058 N74 17729	NO REPORT NUMBER	p0204 N74 23109	NO REPORT NUMBER
p0221 N74 14300	NO REPORT NUMBER	p0058 N74 17730	NO REPORT NUMBER	p0204 N74 23110	NO REPORT NUMBER
p0221 N74 14301	NO REPORT NUMBER	p0058 N74 17731	NO REPORT NUMBER	p0204 N74 23111	NO REPORT NUMBER
p0221 N74 14302	NO REPORT NUMBER	p0058 N74 17732	NO REPORT NUMBER	p0204 N74 23112	NO REPORT NUMBER
p0221 N74 14303	NO REPORT NUMBER	p0058 N74 17733	NO REPORT NUMBER	p0305 N74 23492	NO REPORT NUMBER
p0221 N74 14304	NO REPORT NUMBER	p0059 N74 17734	NO REPORT NUMBER	p0306 N74 23493	NO REPORT NUMBER
p0221 N74 14305	NO REPORT NUMBER	p0059 N74 17735	NO REPORT NUMBER	p0306 N74 23494	NO REPORT NUMBER
p0222 N74 14306	NO REPORT NUMBER	p0059 N74 17736	NO REPORT NUMBER	p0306 N74 23495	NO REPORT NUMBER
p0222 N74 14307	AGARD LS 60	p0059 N74 17737	NO REPORT NUMBER	p0306 N74 23496	NO REPORT NUMBER
p0226 N74 14345	NO REPORT NUMBER	p0059 N74 17738	NO REPORT NUMBER	p0306 N74 23497	NO REPORT NUMBER
p0226 N74 14346	NO REPORT NUMBER	p0059 N74 17739	NO REPORT NUMBER	p0306 N74 23498	NO REPORT NUMBER
p0226 N74 14347	NO REPORT NUMBER	p0059 N74 17740	NO REPORT NUMBER	p0306 N74 23499	NO REPORT NUMBER
p0226 N74 14348	NO REPORT NUMBER	p0059 N74 17741	NO REPORT NUMBER	p0306 N74 23500	NO REPORT NUMBER
p0226 N74 14349	NO REPORT NUMBER	p0059 N74 17742	NO REPORT NUMBER	p0306 N74 23501	NO REPORT NUMBER
p0226 N74 14350	NO REPORT NUMBER	p0060 N74 17743	NO REPORT NUMBER	p0149 N74 73499	AGARD AP 42
p0226 N74 14351	NO REPORT NUMBER	p0060 N74 17744	NO REPORT NUMBER	p0149 N74 73199	AGARD AR 42 REV
p0227 N74 14352	NO REPORT NUMBER	p0060 N74 17745	NO REPORT NUMBER	1061 N74 73500	AGARD AR 47 VOL 1
p0227 N74 14353	NO REPORT NUMBER	p0060 N74 17746	NO REPORT NUMBER	p0061 N74 73501	AGARD AR 47 VOL 2
p0227 N74 14354	NO REPORT NUMBER	p0023 N74 18652	AGARD R 611	p0061 N74 73502	AGARD AR 47 VOL 3
p0227 N74 14355	NO REPORT NUMBER	p0023 N74 18653	NASA TM X 69997	p0306 N74 73503	AGARD AR 57 VOL 1
p0227 N74 14356	NO REPORT NUMBER	p0023 N74 18654	AGARD R 612	p0307 N74 73504	AGARD AR 57 VOL 2
p0018 N74 14709	AGARD CP 124	p0088 N74 18779	AGARD R 614	p0307 N74 73505	AGARD CP 72
p0019 N74 14710	NO REPORT NUMBER	p0088 N74 18780	AGARD CP 133	p0061 N74 73506	AGARD CP 126 VOL 2
p0019 N74 14711	NO REPORT NUMBER	p0088 N74 18781	NO REPORT NUMBER	p0061 N74 73507	
p0019 N74 14712	NO REPORT NUMBER	p0088 N74 18782	NO REPORT NUMBER		
p0019 N74 14713	NO REPORT NUMBER	p0088 N74 18783	NO REPORT NUMBER		
p0019 N74 14714	NO REPORT NUMBER	p0088 N74 18784	NO REPORT NUMBER		
p0019 N74 14715	NO REPORT NUMBER	p0088 N74 18785	NO REPORT NUMBER		
p0019 N74 14716	NO REPORT NUMBER	p0088 N74 18786	NO REPORT NUMBER		
p0020 N74 14717	NO REPORT NUMBER	p0088 N74 18787	NO REPORT NUMBER		
p0020 N74 14718	NO REPORT NUMBER	p0088 N74 18788	NO REPORT NUMBER		
p0020 N74 14719	NO REPORT NUMBER	p0088 N74 18789	NO REPORT NUMBER		
p0020 N74 14720	NO REPORT NUMBER	p0089 N74 18790	NO REPORT NUMBER		
p0020 N74 14721	NO REPORT NUMBER	p0089 N74 18791	NO REPORT NUMBER		
p0020 N74 14722	NO REPORT NUMBER	p0106 N74 18797	AGARD CP 132		
p0020 N74 14723	NO REPORT NUMBER	p0106 N74 18798	NO REPORT NUMBER		
p0020 N74 14724	NO REPORT NUMBER	p0107 N74 18799	NO REPORT NUMBER		
p0021 N74 14725	NO REPORT NUMBER	p0107 N74 18800	NO REPORT NUMBER		
p0021 N74 14726	NO REPORT NUMBER	p0107 N74 18801	NO REPORT NUMBER		
p0021 N74 14727	NO REPORT NUMBER	p0107 N74 18802	NO REPORT NUMBER		
p0021 N74 14728	NO REPORT NUMBER	p0107 N74 18803	NO REPORT NUMBER		
p0021 N74 14729	NO REPORT NUMBER	p0107 N74 18804	NO REPORT NUMBER		
p0021 N74 14730	NO REPORT NUMBER	p0184 N74 18923	AGARD AG 173		
p0021 N74 14731	NO REPORT NUMBER		AGARDUOGRAPH 173		
p0022 N74 14732	NO REPORT NUMBER	p0184 N74 18924	AGARD AG 174		
p0022 N74 14733	NO REPORT NUMBER		AGARDUOGRAPH 174		
p0022 N74 14734	NO REPORT NUMBER	p0298 N74 19550	AGARD AG 162 PT 3		
p0022 N74 14735	NO REPORT NUMBER		AGARDUOGRAPH 162 PT 3		
p0022 N74 14736	NO REPORT NUMBER	p0060 N74 19552	AGARD CP 141		
p0022 N74 14737	NO REPORT NUMBER	p0060 N74 19553	NO REPORT NUMBER		
p0022 N74 14738	NO REPORT NUMBER	p0060 N74 19554	NO REPORT NUMBER		
p0222 N74 15549	AGARD AR 63	p0060 N74 19555	NO REPORT NUMBER		
p0295 N74 15596	AGARD CP 123	p0060 N74 19556	NO REPORT NUMBER		
p0295 N74 15597	NO REPORT NUMBER	p0061 N74 19557	NO REPORT NUMBER		
p0296 N74 15598	NO REPORT NUMBER	p0061 N74 19558	NO REPORT NUMBER		
p0296 N74 15599	NO REPORT NUMBER	p0061 N74 19559	NO REPORT NUMBER		
p0296 N74 15600	NO REPORT NUMBER	p0061 N74 19560	NO REPORT NUMBER		
p0296 N74 15601	NO REPORT NUMBER	p0107 N74 20732	AGARD CP 128		
p0296 N74 15602	NO REPORT NUMBER	p0108 N74 20733	NO REPORT NUMBER		
p0296 N74 15603	NO REPORT NUMBER	p0108 N74 20734	NO REPORT NUMBER		
p0296 N74 15604	NO REPORT NUMBER	p0108 N74 20735	NO REPORT NUMBER		
p0297 N74 15605	NO REPORT NUMBER	p0108 N74 20736	NO REPORT NUMBER		
p0297 N74 15606	NO REPORT NUMBER	p0108 N74 20737	NO REPORT NUMBER		
p0297 N74 15607	NO REPORT NUMBER	p0108 N74 20738	NO REPORT NUMBER		
p0297 N74 15608	NO REPORT NUMBER	p0108 N74 20739	NO REPORT NUMBER		
p0297 N74 15609	NO REPORT NUMBER	p0108 N74 20740	NO REPORT NUMBER		
p0297 N74 15610	NO REPORT NUMBER	p0108 N74 20741	NO REPORT NUMBER		
p0297 N74 15611	NO REPORT NUMBER	p0109 N74 20742	NO REPORT NUMBER		
p0297 N74 15612	NO REPORT NUMBER	p0109 N74 20743	NO REPORT NUMBER		
p0298 N74 15613	NO REPORT NUMBER	p0109 N74 20744	NO REPORT NUMBER		
p0298 N74 15614	NO REPORT NUMBER	p0109 N74 20745	NO REPORT NUMBER		
p0298 N74 15615	NO REPORT NUMBER	p0109 N74 20746	NO REPORT NUMBER		
p0298 N74 15616	NO REPORT NUMBER	p0109 N74 20747	NO REPORT NUMBER		
p0298 N74 15617	NO REPORT NUMBER	p0109 N74 20748	NO REPORT NUMBER		
p0159 N74 18925	AGARD CP 136	p0109 N74 20749	NO REPORT NUMBER		
p0159 N74 18926	NO REPORT NUMBER	p0110 N74 20750	NO REPORT NUMBER		
p0159 N74 18927	NO REPORT NUMBER	p0110 N74 20751	NO REPORT NUMBER		
p0160 N74 18928	NO REPORT NUMBER	p0110 N74 20752	NO REPORT NUMBER		
p0160 N74 18929	NO REPORT NUMBER	p0110 N74 20753	NO REPORT NUMBER		
p0160 N74 18930	NO REPORT NUMBER	p0110 N74 20754	NO REPORT NUMBER		
p0160 N74 18931	NO REPORT NUMBER	p0110 N74 20755	NO REPORT NUMBER		
p0160 N74 18932	NO REPORT NUMBER	p0304 N74 21610	NO REPORT NUMBER		
p0160 N74 18933	NO REPORT NUMBER	p0305 N74 21611	NO REPORT NUMBER		
p0160 N74 18934	NO REPORT NUMBER	p0305 N74 21612	NO REPORT NUMBER		
p0160 N74 18935	NO REPORT NUMBER	p0305 N74 21613	NO REPORT NUMBER		
p0160 N74 18936	NO REPORT NUMBER	p0305 N74 21614	NO REPORT NUMBER		
p0161 N74 18937	NO REPORT NUMBER	p0305 N74 21615	NO REPORT NUMBER		
p0161 N74 18938	NO REPORT NUMBER	p0305 N74 21616	NO REPORT NUMBER		
p0161 N74 18939	NO REPORT NUMBER	p0305 N74 21617	NO REPORT NUMBER		
p0173 N74 18987	AGARD R 600	p0305 N74 21618	NO REPORT NUMBER		
p0173 N74 18988	NO REPORT NUMBER	p0061 N74 22634	AGARD LS 54		
p0174 N74 18989	NO REPORT NUMBER	p0089 N74 22727	AGARD AG 174		
p0174 N74 18990	NO REPORT NUMBER		AGARDUOGRAPH 174		
p0174 N74 18991	NO REPORT NUMBER		AGARDUOGRAPH 174		
p0174 N74 18992	NO REPORT NUMBER	p0111 N74 22799	AGARDUOGRAPH 174		
p0174 N74 18993	NO REPORT NUMBER		AGARDUOGRAPH 174		
p0304 N74 17664	AGARD CP 140	p0184 N74 22914	AGARDUOGRAPH 174		
p0057 N74 17722	NO REPORT NUMBER	p0185 N74 22915	AGARDUOGRAPH 174		
p0057 N74 17721	NO REPORT NUMBER	p0185 N74 22916	AGARDUOGRAPH 174		
p0057 N74 17722	NO REPORT NUMBER	p0185 N74 22917	AGARDUOGRAPH 174		
p0057 N74 17723	NO REPORT NUMBER	p0185 N74 22918	AGARDUOGRAPH 174		
p0057 N74 17724	NO REPORT NUMBER	p0185 N74 22919	AGARDUOGRAPH 174		
p0058 N74 17725	NO REPORT NUMBER		AGARDUOGRAPH 174		

# DISTRIBUTION OF UNCLASSIFIED AGARD PUBLICATIONS

NOTE: Initial distributions of AGARD unclassified publications are made to NATO Member Nations through the following National Distribution Centres. Further copies are sometimes available from these Centres, but if not may be purchased in Microfiche or photocopy form from the Purchase Agencies listed below. THE UNITED STATES NATIONAL DISTRIBUTION CENTRE (NASA) DOES NOT HOLD STOCKS OF AGARD PUBLICATIONS, AND APPLICATIONS FOR FURTHER COPIES SHOULD BE MADE DIRECT TO THE APPROPRIATE PURCHASE AGENCY (NTIS).

## NATIONAL DISTRIBUTION CENTRES

### BELGIUM

Coordonnateur AGARD - VSL  
Etat-Major de la Force Aérienne  
Caserne Prince Baudouin  
Place Dailly, 1030 Bruxelles

### CANADA

Defence Scientific Information Service  
Department of National Defence  
Ottawa, Ontario K1A 0Z3

### DENMARK

Danish Defence Research Board  
Østerbrogades Kaserne  
Copenhagen Ø

### FRANCE

O.N.E.R.A. (Direction)  
29, Avenue de la Division Leclerc  
92, Châtillon sous Bagneux

### GERMANY

Zentralstelle für Luftfahrtokumentation  
und Information  
8 München 86  
Postfach 860881

### GREECE

Hellenic Armed Forces Command  
D Branch, Athens

### ICELAND

Director of Aviation  
c/o Flugrad  
Reykjavik

### ITALY

Aeronautica Militare  
Ufficio del Delegato Nazionale all'AGARD  
3, Piazzale Adenauer  
Roma/EUR

### LUXEMBOURG

See Belgium

### NETHERLANDS

Netherlands Delegation to AGARD  
National Aerospace Laboratory, NLR  
P.O. Box 126  
Delft

### NORWAY

Norwegian Defence Research Establishment  
Main Library  
P.O. Box 25  
N-2007 Kjeller

### PORTUGAL

Direccao do Servico de Material  
da Forca Aerea  
Rua de Escola Politecnica 42  
Lisboa  
Attn: AGARD National Delegate

### TURKEY

Turkish General Staff (ARGE)  
Ankara

### UNITED KINGDOM

Defence Research Information Centre  
Station Square House  
St. Mary Cray  
Orpington, Kent BR5 3RE

### UNITED STATES

National Aeronautics and Space Administration (NASA)  
Langley Field, Virginia 23365  
Attn: Report Distribution and Storage Unit  
(See Note above)

## PURCHASE AGENCIES

### Microfiche or Photocopy

National Technical  
Information Service (NTIS)  
5285 Port Royal Road  
Springfield  
Virginia 22151, USA

### Microfiche

ESRO/ELDO Space  
Documentation Service  
European Space  
Research Organization  
114, Avenue Charles de Gaulle  
92200 Neuilly sur Seine, France

### Microfiche

Technology Reports  
Centre (DTI)  
Station Square House  
St. Mary Cray  
Orpington, Kent BR5 3RF  
England

Requests for microfiche or photocopies of AGARD documents should include the AGARD serial number, title, author or editor, and publication date. Requests to NTIS should include the NASA accession report number.

• • •

Full bibliographical references and abstracts of AGARD publications are given in the following bi-monthly abstract journals:

Scientific and Technical Aerospace Reports (STAR),  
published by NASA,  
Scientific and Technical Information Facility  
P.O. Box 33, College Park  
Maryland 20740, USA

Government Reports Announcements (GRA),  
published by the National Technical  
Information Service, Springfield  
Virginia 22151, USA

